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JÖSSINGFJORD: LOCALITY OF FIRST ELECTRIC STEEL WORKS INSTALLED IN NORWAY.

FIRST NORWEGIAN ELECTRIC STEEL WORKS.—[SEE PAGE 376.]

THE CENTRALIZATION OF POWER.*

THE FUTURE OF ELECTRICITY AS A CONSERVER OF FUEL SUPPLY.

BY S. Z. DE FERRANTI.

THERE are few subjects more important to the people of this country than the question of the rapid and ever-growing rate at which we are using up our coal supplies. Many writers have dealt with this subject and have suggested various remedies.

It may be said that the rate at which we can use coal is a measure of our industrial activity and prosperity. This would be true, perhaps, if we were using our coal without waste, or at least with reasonable economy, but it is certainly not true of what we are at present doing.

Taking all the uses for coal into consideration, I believe that we are getting back an amount represented by useful work of one kind or another of much less than 10 per cent of the energy in the coal. We can never, of course, hope to get anything like the full value of the energy in the coal, but, on the other hand, throwing away more than 90 per cent of the value of our coal in the process of conversion is of the greatest possible concern to the country. Moreover, there is a further waste involved in our present methods of using coal which is only second in importance to the one I have spoken of. We now dissipate nearly the whole of the valuable by-products contained in the coal, consisting principally of fixed nitrogen.

It is in the process of transformation of coal into work in the form of heat and power that the great loss occurs, as this is always a most difficult process, and requires the highest scientific and practical skill to carry out with even very moderate economy.

It has been proposed, with the view of accomplishing the above ends, to treat the coal at central stations and turn it into gas and distribute the energy in this form, but this process only goes a small way toward a solution of the problem, as under it combustion—which is such a difficult problem—would be taking place at numerous points over the whole country, all tending to inefficiency, and the conversion of the gas into power is by no means easy, involving running machinery of the reciprocating class, requiring special and skilled attendance.

It appears that with a problem such as we are discussing it is fundamental that the energy in the coal should be converted at as few centers as possible into a form in which it is most generally applicable to all purposes without exception, and in which it is most easily applied to all our wants, and is, at the same time, in a form in which it is most difficult to waste or use improperly.

We are therefore forced to the conclusion that the only complete and final solution of the question is to be obtained by the conversion of the whole of the coal which we use for heat and power into electricity, and the recovery of its by-products at a comparatively small number of great electricity-producing stations. All our wants in the way of light, power, heat, and chemical action would then be met by a supply of electricity distributed all over the country.

It must, however, be remembered that the distribution of energy in the form of electricity instead of coal can only be effectively carried out when it can be done in such a way that it is available for all the purposes for which coal is now used, and this can only be the case when the conversion is effected at such an efficiency as will cause the electric energy delivered to represent a high percentage of the energy in the coal. Failing this, no scheme for conversion at the pit's mouth and delivery of energy in the form of electricity is sound. There is also another controlling factor which must be satisfied in order to make this scheme possible. Both the conversion of the coal into electricity and the distribution of the current must be effected at a low capital cost, so as not to overburden the undertaking with capital charges.

Considering the various processes of conversion which are now available, or may be invented, and their possible and probable efficiency, we first come to electric generators driven by reciprocating steam engines. Their economy, expressed in the form of energy in the coal to electric energy, may be taken as a maximum of 10 to 12 per cent. This is, of course, far too low an efficiency to make any scheme such as I have already indicated possible, besides which the capital expenditure and the complication involved are far too great and the size of the units too small to be thought of for the purpose in view.

We next come to large steam turbines such as have been constructed up to the present, and see that their maximum efficiency may be put down at about 17 to 18 per cent.

Next in the list, in order of economy, comes the big gas engines fed from gas-producers, with an efficiency of coal energy to electric energy of possibly 25 per cent.

In the future we have to look toward two other means of conversion—the gas-turbine-driven electric generator and the production of electricity in some more direct way from the coal; but these two means of conversion, although being capable of giving the most efficient results, are so much in the distance that they are quite beyond our present consideration.

After very careful thought on the subject I have come to the conclusion that, in order to supply electricity for all purposes, it would be necessary, among other things, to have a conversion efficiency of not less than 25 per cent.

For the purpose of looking into this question I have taken the figures of production and consumption given in the report of the Royal Commission on Coal, which clearly summarizes the position as it stood a few years ago, and as the increase taking place is fairly regular, these figures have been taken throughout. According to this report 167 million tons of coal were being used in the country in 1903. Of this amount 2 million tons went to coasting steamers and 15 million tons were used by the gas companies. In order to simplify matters and make the figures clear, I have left out of consideration the coal used on these two items, and taken the balance—viz., 150 million tons—as the annual coal consumption of the country. If now, instead of using this coal for doing work, as at present, we were to convert it into electricity, we should use, instead of 150 million tons, 60 million tons of coal a year. This coal, turned into electricity, would produce 131,400 million Board of Trade units, and the electricity so produced would, after allowing for losses of transmission and conversion into work of different kinds, be sufficient to supply the whole of our requirements now being satisfied by the use of the 150 million tons of coal which we now burn.

Summarizing the whole position, it may safely be said that, wherever coal, gas, or power are now used, everything for which they are used will be better done when electricity is the medium of application.

Hardly less in importance in the all-electric scheme is the question of the by-products which become available by the proper use of our coal. These consist principally of fixed nitrogen, together with tar and oils.

Fixed nitrogen in the forms of sulphate of ammonia, nitrate of soda, and nitrate of lime are most valuable fertilizers, and enable land continually to produce the same crops with a greatly increased yield per acre. Much has been done in finding out how best to utilize these artificial fertilizers, but no doubt a great deal more will be done in this direction, and fertilizers will be prepared, with fixed nitrogen as their principal constituent, which best suit the particular soils and crops that it is desired to deal with.

According to last year's Board of Trade returns, we now grow about 23 per cent of the total wheat that we use and import 77 per cent. Of the barley used we grow 59 per cent and import 41 per cent, and of the oats used 78 per cent is home grown and 22 per cent imported. Last year we devoted 7¾ million acres to the cultivation of these crops.

Much is being done to improve the yield of corn crops, and it is probable that with scientific treatment in the production of the seed, in the sterilization of the ground, and in the application of fertilizer, we may look at no distant date to an increased yield of 50 per cent in these crops upon what is now being produced per acre. The most vital feature, however, in bringing this about, once we have acquired sufficient knowledge, is an ample supply of fixed nitrogen to use as fertilizer, and it is when considered from this point of view that a scheme which supplies this from our coal as the result of saving present waste is most important.

With the increased yield which we have mentioned we could produce corn crops sufficient to supply the whole of our requirements upon 11 million acres. This would represent 23½ per cent of our present cultivated area, and would only be an addition of 3 1/3 million acres to the land now used for the purpose of growing these same crops. The value of these additional crops would be about 58 millions sterling, based upon the prices which we paid last year, and to this would have to be added the value of the straw and the other wheat by-products, which would go a long way toward providing the food for growing the additional meat which we require to supply our demand at home.

In order to fertilize the land we should have available, under the all-electric scheme, 3 million tons, or its nitrogen equivalent, of sulphate of ammonia. This, if used over the whole of the 46¾ million acres now under cultivation, would give 143 pounds per acre; but, of course, the fertilizer would be distributed according to the nature of the land and the crops being grown. It is probable that in these circumstances the increased yield of the land now cultivated would not only give us all the grain that we should require for food, but also all the foodstuffs, partly as by-product from the grain and partly grown, that would be required for raising the cattle, sheep, and other animals necessary to supply the whole of our wants.

It is now beginning to be understood that intensive farming of the land also involves intensive cattle raising, and that it is very advantageous greatly to reduce the amount of grass land and instead to grow crops intensively cultivated, as in this way a given amount of land can be made to produce a much larger yield.

Sulphate of ammonia is a particularly good fertilizer, for the purpose of growing sugar beet, and here again it is probable that the availability of large quantities of this fertilizer at a very much lower price than at present prevails would enable us to produce the whole of our sugar at home, especially as the by-product, obtained in the form of crushings from the beet, is a very valuable food for cattle raising, and also as the crop is a very suitable one for growing alternately with wheat.

If it was found that a larger amount of fertilizer than the 3 million tons of sulphate of ammonia, which would be the principal by-product from 60 million tons of coal turned into electricity, could be advantageously used, this would be very economically produced from the electrical station by the oxidation of atmospheric nitrogen, giving a valuable fertilizer in the form of nitrate of lime. This could be made intermittently by means of current filling up the load curve, and would not necessitate the expenditure of any more money on plant for generation or transmission of the current. It would, however, require the burning of additional coal, and this in itself would add to the sulphate of ammonia available.

It is assumed by many people that the climate of this country is largely unsuitable for the purpose of growing food, and for this reason it is thought that we can never grow the food which we require. This is largely a misconception, as crops both large in quantity and of good quality can be produced in this country. Nevertheless, it would be a desirable thing if, instead of the dark weather that we now often experience owing to cloud obstruction, we could have continuous sunshine at certain times of the year. The amount of sunshine would, no doubt, be largely increased by the abolition of all smoke in the air, as not only does the smoke itself obscure the sun, but also it seems to have the effect of assisting the formation of cloud, which greatly diminishes the light and heat which we receive.

At present it is considered quite right and reasonable to canalize rivers and make great works for adding to the fertility of countries by means of irrigation, but I believe that in the future the time will come when it will be thought no more wonderful largely to control our weather than it is now thought wonderful to control the water after it has fallen on the land. I think that it will be possible to acquire knowledge which will enable us largely to control by electrical means the sunshine which reaches us, and, in a climate which usually has ample moisture in the atmosphere, to produce rainfall when and where we require it.

It seems to me that it may be possible, when we know a great deal more about electricity than we do to-day, to set up an electrical defense along our coasts by which we could cause the moisture in the clouds to fall in the form of rain, and so prevent these clouds drifting over the country between ourselves and the sun which they now blot out. It also seems to me that it will be possible, when more water on the country is required, to cause the falling of rain from the clouds passing over the highest part of the country, and so produce an abundance of water which, properly used, would greatly add to the fertility of the country.

Of course, it may seem that these are only mad visions of the future, but I think we can hardly con-

* From the inaugural address delivered at the Institution of Electrical Engineers on November 10th, by Mr. S. Z. de Ferranti.

sider these results more improbable than anyone would have considered wireless telegraphy or flight in heavier-than-air machines fifty years ago. My excuse for mentioning these matters here is that they might constitute another great use of electricity, and their useful consummation would certainly be facilitated by an abundant supply of electrical energy.

At present, although the using of our coal may mean commercial activity, it certainly means the desolation of the country in parts where it is largely used. Instead of this harm being done to the country by our coal, we should fertilize the lands by its means, and might even, as I have indicated, use it in the future to increase our sunshine. Of course there are many things which at present stand in the way of realizing such a scheme as I have outlined. There are many technical details which nothing but an immense amount of work can solve satisfactorily. There are also political and legislative difficulties standing in the way, but these, when the time arrived, would have to be got rid of rather than allow them to handicap the advance of the country. The more, however, that I have considered these ideas in detail, the more certain am I of the fundamental soundness underlying them, and that it is only a matter of time before such a scheme is carried out in its entirety. What interests us most, perhaps, is the question of how long it is likely to be before the all-electric idea becomes possible. At present there is so much required to be done to make it workable in all its details that it seems as though its realization would be long deferred. It must, however, be remembered that knowledge is continually being acquired which brings us nearer to its realization, and that things engineering, and especially in electrical engineering, now move very rapidly. It may therefore come to pass that the all-electric idea with its far-reaching changes and great benefits will become an accomplished fact in the near future.

DE FERRANTI AND FUTURE POWER.

A CRITIQUE OF A REMARKABLE PAPER.

When a popular writer paints a fanciful or prophetic vision of the future he invariably pictures it as being founded on a basis of electricity. His reason for assuming this force as the motive power of all his marvels is not far to seek. Since he has generally no knowledge of the limitations of the subject, and can assume an equal ignorance on the part of his readers, his fancy can roam without restriction, and can endue the creations of his brain with capacities which not only transcend all experience, but which also disregard logical deduction from known facts. His heroes are not fettered with a consciousness of the existence of the dogma of the conservation of energy, and they habitually get something out of nothing with the facility of a conjurer on the stage. In the hands of a clever writer, with a mastery of style, the result is sometimes very delightful, and, in imagination, his readers can revel in capabilities and powers which, for the moment, make them forget their human origins. They realize the scriptural assertion "Ye are gods," and in thought they work marvels never yet beheld on land or sea. Even an engineer may be carried off his feet in this way, and casting behind him all his knowledge and the caution born of a long struggle with the powers of Nature, may enjoy an hour or two of freedom in a world where all material things bend to his will. It is, however, only for a brief spell. The keen logic of fact clips the wings of his imagination as soon as he returns to his daily work, and does it so thoroughly that he is generally unable to take the shortest flight into the empyrean on his own initiative.

Lack of imagination is a disability from which engineers as a class suffer most seriously, and which is the obstacle standing between them and the position they ought to take in the world on account of the immense services they render to it. Their daily struggle with intractable matter, their constant battle with the forces of Nature, the unremitting care they expend upon detail, are all opposed to the growth of that intellectual freedom which enables a man to ascend to mental heights and take a wide survey of the present and the future. Even when the occasion cries out for such treatment, we often see engineers of the greatest eminence refusing the appeal, and deliberately keeping their eyes on the earth, instead of directing them to the horizon to pierce the mists which guard the distant view from their less elevated brethren. If there ever be an opportunity in an engineer's life when he should discard detail and fix his vision on principles, when he should bring forth the essence distilled from years of experience, when he should loose his hold upon mere facts and declare his faith—it is when his fellow-engineers place him in the proud position of the head of his profession, and gather to hear such words of wisdom as may fall from his lips.

Sad to relate, it is only a minority of engineers that grasp such an occasion. Some recreant in the long past enunciated the absurd contention that a presidential address should not be controversial, and many a faint-hearted successor has endeavored to hide his intellectual insufficiencies behind it. It has been repeated *ad nauseam* that since courtesy prevents such an address being controverted, it might give currency to dangerous errors if it dealt with matters which could not be demonstrated by simple arithmetic. The logical result of such an argument would be the abolition of inaugural addresses, for outside geometry it is impossible to speak for five minutes without giving utterance to remarks that may be controversial. Statistics, the refuge of many a president, are continually proving to be a battleground on which the fiercest conflicts may be waged. The same figures make one man a furious free trader and another a staunch tariff reformer. All statements which are not truisms must be contentious; but many are so remote from all intellectual and scientific interest that they are not worth fighting about, and it is these which often constitute the staple of the addresses which open the sessions of our technical institutions. In no other walk of life is this cult of deadly dullness so steadily followed. Even the most dogmatic of Christian churches admits degrees in the matter of truth. All truth is not *de fide*, and when there is matter for comparison there is subject for controversy. The diminution of the power of the pulpit, which one sees debated from time to time in the daily press, has proceeded step by step with the growing practice of the preacher to avoid those polemical topics upon which the divines of an earlier age sought to build their reputation. Politics, the drama, literature, and science owe their attraction to the controversies they engender; if there were no differences of opinion regarding them, they would be as dull as a diet of ditch water. The man who leads in the legislature, the author who sells his books, the dramatist who attracts the public, is the one who boldly proclaims his ideas, and offers to maintain them against all comers. He may succeed, or he may fail, but in any case he stimulates the brains of less energetic or less courageous people, and helps to make the world go round.

Fortunately, such men are not entirely lacking in the ranks of engineers, although they are scarce. From time to time they come forward to redeem the profession from the stigma of intellectual myopia, and only this month we have had the privilege of listening to two addresses calculated to widen the outlook of the audience. Mr. Alexander Siemens pressed on the members of the Institution of Civil Engineers the lessons to be learned from philosophy, and their application to our times. More recently (on November 10th) Mr. S. Z. de Ferranti has indulged in a presidential vision (this address will be found on page 370), and has limned for his fellow-members of the Institution of Electrical Engineers a picture of futurity in which electricity will displace all other sources of power and heat, will give security to the country by rendering it independent of foreign sources of food, and will endow us individually with prosperity and with leisure to enjoy it. Here is a matter for controversy with a vengeance, and from the lips of one less gifted by nature to attract and hold the attention of an audience it might either have fallen flat or have been received with ridicule. Neither of these things happened. Mr. Ferranti's courage and his well-known habit of looking far ahead command intellectual respect, while the charms of his voice and manner take captive the senses of an audience. The fact that he spoke his address instead of reading it, that every word fell clear and limpid, without haste and without effort, while the scheme was unfolded step by step in logical sequence, so beguiled his hearers that they were carried away into fairyland quite unconsciously, and when at the close they awoke with a start, the delightful experience disarmed their powers of criticism.

Frankly, it is not an easy matter to criticise Mr. Ferranti, for, unlike the novelist, he understands his subject when he discourses on electricity. Of course, the man in the plain may deride the vision of the horizon proclaimed from the watch-tower, and may assert that nothing exists but what he can see himself. That is done every day, and by no one more frequently than by engineers. But Mr. Ferranti did not let his gaze stray too far. Some part of every subject of which he sketched the development was visible to all the members of the audience, although the wider features could only be discerned by the eye of faith. We may here emphasize the careful way in which a train of stepping stones was laid to each objective, to aid the halting steps of those to whom flights of fancy are impossible. The foundation statement was that from the 150 million tons of coal that we burn in this country per annum we obtain an efficiency of less than 10 per cent. No one will doubt that. This led to the estimate that in the near future we may reasonably expect to convert 25 per cent of the energy of fuel into electric motive power. Already we can obtain 10 per cent by aid of the steam engine, 17 to 18 per cent by large steam turbines, and 25 per cent by gas engines. But gas engines are too small and too expensive for Mr. Ferranti's vision of the future, and he pins his faith to the steam-gas-turbine, in which steam is used in a state of gas at high temperature throughout the process of conversion into work. It is no secret that he has been occupied for years at the subject, and when he says that an efficiency of 25 per cent will be obtained from it some day, even an intellectual cripple may keep step with him.

The next stage in the vision is that the increase of efficiency from 10 to 25 per cent would enable 60 million tons of coal to do the work upon which 150 millions are now expended. Against this gain is to be put the extra cost involved in works charges, interest on capital, and the like, and the result is that the world would be out of pocket on the transaction. But the coal contains a great store of fixed nitrogen, which is now wasted, although it is well known to be a most valuable fertilizer. Mr. Ferranti reckons that a hundredweight of sulphate of ammonia could be got from each ton of coal with improved processes, although we believe this is more than 50 per cent beyond what is obtained now. Against that, however, he reduces the value from £12 to £8 a ton. Rising prices do not enter into his vision; in present-day experience engineers could not follow him along that line. Of course, the extraction of ammonia involves the gasification of the coal, and so far there is no available process to fix the nitrogen and to make a gas advantageous to burn under boilers at the same time. Either can be done separately, but we must look to the future for the two processes to be worked together. But even with 24 millions sterling as the value of the ammonia to the credit side of the account, the price of electric energy is still too high to enable it to be used for every purpose in life unless the load-factor of the stations can be increased to 60 per cent. At one favored spot a load-factor of 33 per cent is already attained, so that we are more than half way to that goal.

Under these hypothetical conditions, with coal at 10s. a ton, Mr. Ferranti reckons the cost of current at the switchboard at 1/13d. for capital charges and 1/28d. for works cost, or a total of 1/9d. His selling price would be ¼d. on the average, varying from 2d. for lighting to 1/12d. for smelting iron. We must refer our readers to the address itself for further details. We have only given these few particulars to show how careful Mr. Ferranti was not to strain the imagination of his hearers to the breaking point. He seldom asked them to conceive of a process more than about 50 per better than existing processes, and if one looks back five and twenty years it is easy to find very many examples of greater progress than this. We are apt to forget what may happen in a single lifetime. There are a considerable number of people in this country who were alive when there were no railways and no electric telegraphs, and there are children still at school whose birth preceded the advent in this country of motor cars, flying machines, and wireless telegraphy. The public distribution of electric energy was commenced by Mr. Ferranti about twenty-four years ago, and at the time the possibility that the cost would come down to the figure that now prevails at Tyneside was quite as remote as that it may be still further reduced to ¼d. per unit. When Sir William Siemens melted steel in a crucible by the electric arc no one seriously contemplated that within a quarter of a century the electric manufacture of steel would become an every-day process, carried out in a score of places. During that period there has been no great invention in generating machinery or in metallurgy. The dynamo is in essence what it was then, and steel-making has not changed in principle.

Yet the cost of current for power purposes has fallen from 8d. to about ½d., and, in places where there are exceptionally advantageous sources of water power, to near 1/14d. It is the constant march of improvement in detail that creates commercial revolutions. Science may advance by a long stride occasionally, but industry creeps forward at a gradually increasing rate, which attracts little attention, and is often mistaken for immobility. When we look back we see the progress that it has made, but when we look forward we are apt to let our fears dictate to our knowledge, and to protest that no further advance can be attained.

The achievement of Mr. Ferranti's ideal depends on steady progress on several distinct lines, and if failure should supervene in any one, the end will not be reached in the way he suggests. Probably the solution of the problem which he sketches is not the true one, for the gift of prophecy is not accorded to man. The future is always shrouded; but while that is reason for caution, it is also ground for hope. We cannot say with certainty how existing tendencies will develop, and, at the same time, we are ignorant of the possibilities lying hidden before us. We are sure that these tendencies exist—all experience testifies to that—but we do not know what they are or when they will appear.

It is the belief in the continuous improvement of our knowledge, in the unfaltering march of our race toward its mastery over matter, that distinguishes the man of imagination from the mere mechanic. Given a desirable goal, and some avenues leading a fair distance toward it, it is no sign of folly to plunge into them confident that by one's own exertions, or by those of others, a way will eventually be discovered.

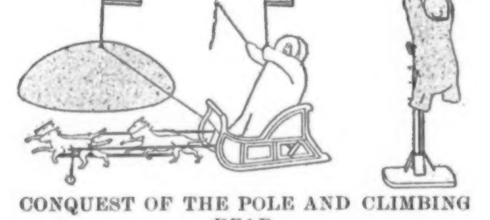
Mr. Ferranti's project does not end by simplifying the supply of heat and light. It includes a great increase in the fertility of our fields, an emancipation from the risks attending over-sea sources of meat and corn, the return of immense numbers of workers to the land, the clearing of our skies from smoke and fog, and the removal from our homes of the dirt connected with the use of coal. These are all by-products, and if attained will be another illustration of the fact that the work of the engineer is the great engine in social amelioration. It lifts the burden of toil from all by substituting steam for human energy, and steel for muscles, it gives leisure to the working classes, and reduces the cost of necessaries of life. Of course, there are risks attending this complex organization. A civilization which largely depends on mechanism is more liable to be thrown into temporary confusion than one founded on a more primitive plan. Wellington compared one of Massena's campaigns in the Peninsula to a set of leather harness for a gun, while his own, he said, was like rope harness. If the leather trace was cut, it was useless, while the rope trace could be mended by a knot. However, in spite of all risks, mankind earnestly travails to free itself from toil, and will not be deterred from increasing the complexity of its organization because it can be shown that thereby it puts itself more into the power of those who seek to fish in troubled waters. Mr. Ferranti has pointed out an attractive line of development for the engineer of the future to pursue, and it remains for his hearers to support their president by each contributing his mite to the elucidation of the many problems that yet remain to be solved before the coal-fed furnace ceases to exist in the land.—Engineering.

UP-TO-DATE TOYS.*

NEW INVENTIONS IN PLAYTHINGS.

CONQUEST OF THE POLE.

Among the toys which appear in great profusion in the shops and streets of Paris shortly before New Year's Day, few are as ingenious and amusing as the mechanical novelties constructed by Martin. The mechanism of most of Martin's toys is very much alike. A spring, wound up by a key, sets in motion a series of wheels, cams, eccentrics and cranks which produce a great variety of movements. The special merit of these toys resides in the amusing and often witty application of this simple mechanism. One of this year's novelties, the Conquest of the Pole, is conceived in a spirit of irony. The polar regions are represented by an inverted sheet iron bowl, appropriately colored blue and white. The pole is indicated by an American flag. A sledge, drawn by six dogs and occupied by an explorer who holds aloft a smaller American flag, is attached to the pole by a cord. When the mechanism is started the sledge careers madly round the pole, but never reaches it.



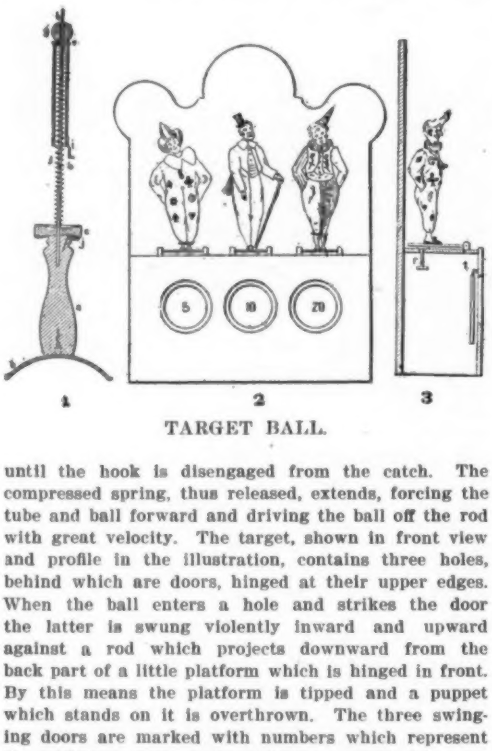
CONQUEST OF THE POLE AND CLIMBING BEAR.

THE CLIMBING BEAR.

The Climbing Bear is of the polar species, and his internal organs consist of springs and wheels which enable him to climb the pole—the North Pole, presumably—in a very graceful manner.

TARGET BALL.

A French abbé has invented a game which he calls Target Ball, and in which balls are thrown at a target by means of an instrument which may be described as a spring gun, the barrel of which, instead of surrounding the ball, is surrounded by it. A longitudinal section of the gun is shown in section 1 of the illustration. The wooden stock, or handle by which the gun is held, is terminated at one end by a curved strip of metal, which is pressed against the breast of the gunner, and at the other end by a rod which passes through the perforated ball and performs the guiding function of an ordinary gun barrel. This rod is surrounded by a spiral spring, the inner end of which presses against a wooden disk which is in contact with the handle and is capable of rotation about the rod. The outer end of the spring is attached to the outer end of a tube which incloses the outer part of the spring, when the latter is extended, and the whole of the spring in its compressed condition. The tube ends in a perforated cap, against which the perforated ball rests, the guiding rod passing through both cap and ball. The inner open end of the tube carries a hook by which the tube can be drawn back, compressing the spring. This hook, passing through an opening in the disk between the spring and the gunstock, is caught and held by a catch attached to the stock. The gun is discharged by turning the disk

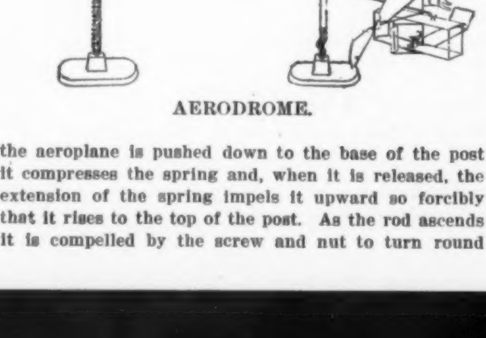


TARGET BALL.

until the hook is disengaged from the catch. The compressed spring, thus released, extends, forcing the tube and ball forward and driving the ball off the rod with great velocity. The target, shown in front view and profile in the illustration, contains three holes, behind which are doors, hinged at their upper edges. When the ball enters a hole and strikes the door the latter is swung violently inward and upward against a rod which projects downward from the back part of a little platform which is hinged in front. By this means the platform is tipped and a puppet which stands on it is overthrown. The three swinging doors are marked with numbers which represent the arbitrary values assigned to the several hits.

THE AERODROME.

Another of these up-to-date toys is the Aerodrome. An aeroplane is suspended from one end of a horizontal rod which carries a counterpoise at the other end. At the middle of the rod is a nut which engages with a screw thread, formed by wrapping a wire spirally round a post. This fixed wire does not extend to the bottom of the post, which is surrounded by a spiral spring. When the horizontal rod which carries

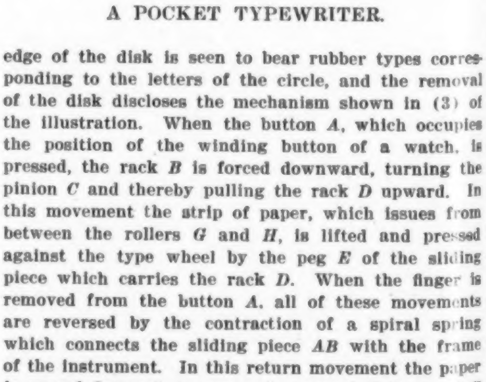


AERODROME.

the aeroplane is pushed down to the base of the post it compresses the spring and, when it is released, the extension of the spring impels it upward so forcibly that it rises to the top of the post. As the rod ascends it is compelled by the screw and nut to turn round the post, carrying the aeroplane with it. As the propeller of the aeroplane revolves rapidly at the same time, a realistic imitation of actual flight is produced.

A POCKET TYPEWRITER.

The typewriter here described and illustrated does not pretend to rival a hundred-dollar machine in rapidity or perfection of operation, but it is so ingeniously contrived that it can be carried in the pocket as conveniently as a large watch, which it closely resembles in appearance. Hence it not only is an instructive toy but, as it can be held in the hand while in operation, it may be employed for writing in a carriage, automobile or railway car, where the use of a pen is impracticable. The letters are printed in a single line on a narrow strip of gummed paper, which may subsequently be cut up and affixed to ordinary sheets. The case of the instrument is about 2½ inches in diameter. The upper lid, like that of some watches, is only a narrow rim, and surrounds a circle of letters and other characters, marked on an interior disk, which is free to rotate. When the lid is removed, the



A POCKET TYPEWRITER.

edge of the disk is seen to bear rubber types corresponding to the letters of the circle, and the removal of the disk discloses the mechanism shown in (3) of the illustration. When the button *A*, which occupies the position of the winding button of a watch, is pressed, the rack *B* is forced downward, turning the pinion *C* and thereby pulling the rack *D* upward. In this movement the strip of paper, which issues from between the rollers *G* and *H*, is lifted and pressed against the type wheel by the peg *E* of the sliding piece which carries the rack *D*. When the finger is removed from the button *A*, all of these movements are reversed by the contraction of a spiral spring which connects the sliding piece *AB* with the frame of the instrument. In this return movement the paper is moved forward one space by means of the pawl *F* and the ratchet wheel *G*. The types are brought to the printing position, as required, by turning the type wheel until the corresponding character of the small circle is opposite a mark on the rim. As the wheel turns, the types are inked by contact with the ink pads *P* and *P*'. The bottom of the case is occupied by the roll of paper.

* From La Nature.

A metallic filament has been patented by I. Kitsee. The metal, in a finely divided state, is converted into the phosphide, and the ingot of the phosphide is then reconverted into the metallic state by electrolysis. The porous ingot thus obtained is hammered and rolled while hot, and is finally drawn into wire while at a lower temperature.

MOTOR LIFEBOATS.*

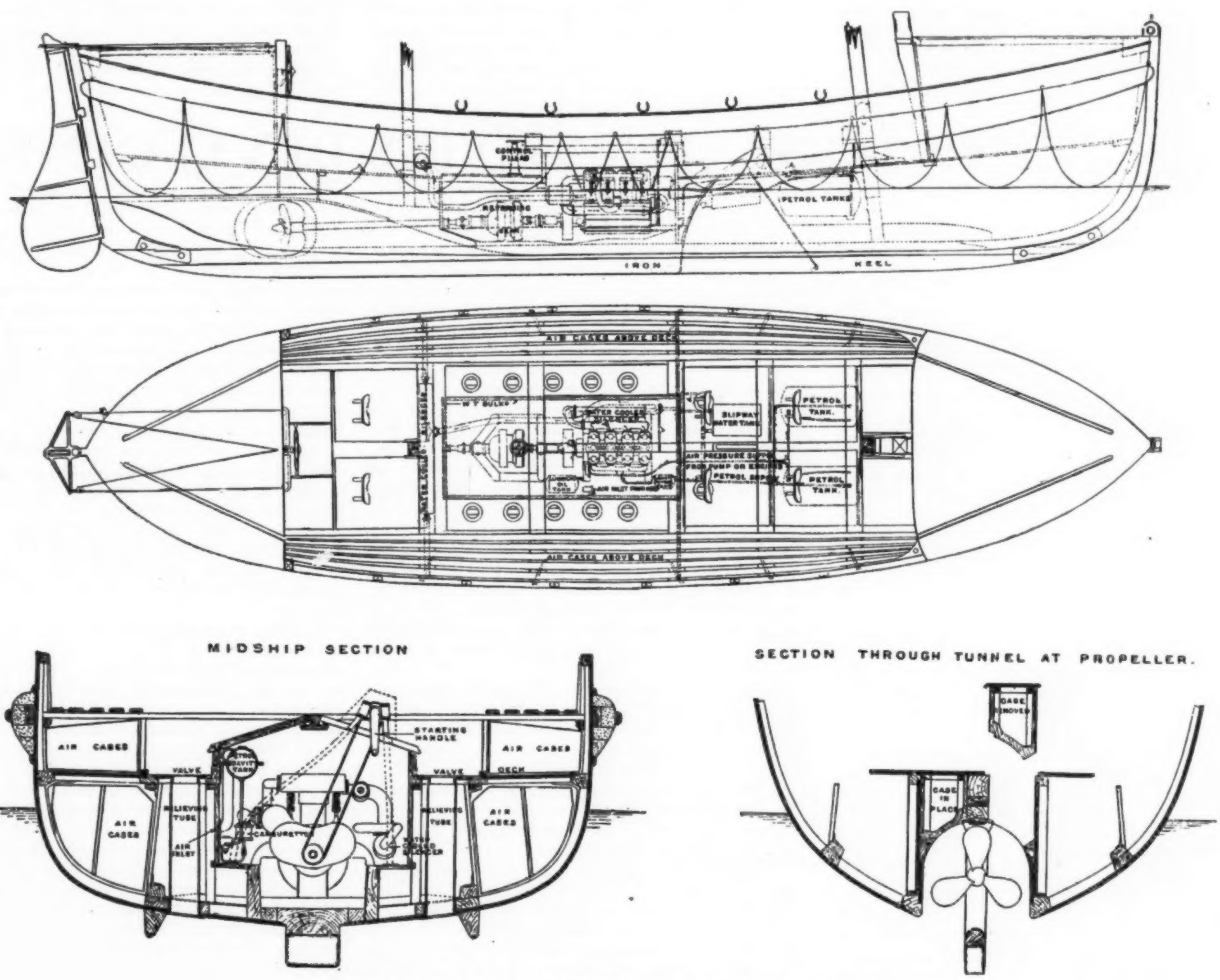
THE ROYAL NATIONAL LIFEBOAT INSTITUTION.

BY J. R. BARNETT, M. R. N. L. I.

As soon as the internal combustion engine became practicable for marine work its adoption for lifeboats was considered. The gasoline engine seemed to make it possible to apply power for the propulsion of the ordinary lifeboats of the Institution. Preliminary and cautious experiments were, therefore, commenced by testing engines of various powers in existing lifeboats of different sizes and types. These boats were converted into motor lifeboats, retaining all the qualities of unsinkableness, relieving and self-righting. The difficulties to be overcome in order that these qualities might remain unimpaired were much greater than might be imagined. But, after some years of such experiments, sufficient success has been attained to and far enough forward to have the trunk hatch clear of the end-box.

But a further stipulation was made. The deadwood aft, which would naturally be cut away by the tunnel, was to be retained, because in these short light-draught boats a good forefoot and heel are necessary to prevent them from being wild in steering. This is a particularly important point, as lifeboats have to work in such broken seas. This condition has been fulfilled by carrying the wood keel aft to the sternpost, and building a continuous deadwood right up the center of the tunnel. As these boats are all built of wood this is a difficult matter, but it has been accomplished by a particularly skillful bit of boat building, would be too complicated to fit one aft of the engine.

The installing of an engine in a boat of this description is not an easy matter, because the difficulties to be contended with are exceptional. It is placed in a water-tight compartment which is metal-lined inside, and it is protected by a water-tight cover or casing, standing above deck, with hinged flaps on top. Of course, it may be quite impossible to open this cover while on service, so the engine must be started, controlled, and run for an indefinite period, without being seen. The fuel and lubricating supply carried is sufficient for twelve hours running. Air is admitted to the carbureter by indirect communication with the atmosphere, as spray or water would be apt



LATEST DESIGN OF A SELF-RIGHTING MOTOR LIFEBOAT.

warrant a further advance being made. A few specially designed motor lifeboats have, therefore, been built for service, and it is to these that attention is now briefly directed.

From the experience gained up to this point certain impressions were confirmed, and certain conditions to be complied with were formulated. First of all the types remain unaltered, and the engine is so far merely auxiliary. It is considered unwise at present to put motors into the smaller lifeboats that are transported by, and launched from, carriages. The risks of damage to the propeller and machinery are too great in the case of the carriage boats. Only boats kept afloat in harbors, or launched from shipways, are at present considered suitable for motor power.

It has been laid down as essential that the propeller should be thoroughly protected, both at the sides and beneath; that it should be sufficiently far forward to prevent its coming constantly out of the water; and that it should be accessible from the inside of the boat by a water-tight trunk hatch from the deck, so that it can be cleared of any obstruction such as ropes or seaweed, while afloat. These conditions make it necessary to place the propeller in a tunnel,

* The Engineer.

and the result has been very satisfactory. The steering is all that could be desired, and the propeller is thoroughly protected and kept well immersed. It may here be mentioned that a wheel for steering has become the popular plan in these boats, displacing the tiller.

An aperture is formed in the deadwood for the propeller to work in. A bronze frame is fitted right round this aperture to take the wood ends, and it is tapered in shape to reduce resistance, the deadwood being necessarily so very thick, in some cases about one-third the diameter of the propeller. As the keel is very broad amidships, tapering forward and aft, this makes the fore end of the tunnel more difficult to construct, while keeping to the true form.

In these motor lifeboats, as the engine is, at the present time, only auxiliary, the sails and oars are retained. These have to be conveniently stowed, and at the same time they must not interfere with the working of the motor. The two masts are, therefore, stepped in their tabernacles, and when sail is not set they are lowered into crutches, which keep them clear of the engine casing. The oars, as usual, are stowed along each side of the boat. Where an engine is installed only the forward drop keel is retained, as it

to find a way into the compartment by any direct ventilator. The air is, therefore, drawn from the hold of the boat, through a large water-tight bend fitted inside the engine compartment for that purpose. Air enters the hold through the valves fitted at the top of each end-box bulkhead, from which pipes are carried down to the hold. This arrangement serves a double purpose. Besides supplying air to the engine, it ventilates the hold, a very important and otherwise difficult matter. As the hold is completely filled with air cases, there are only the small air spaces between these cases through which to draw the air. The arrangement has, however, answered admirably, when tested during continuous running in very dirty weather.

In self-righting boats there is a further difficulty to be overcome. Should the boat be upset it is necessary to stop the engine instantly, because the crew may be thrown into the water, and on righting the boat might run off, leaving them behind. An automatic cut-out switch is, therefore, fitted to the ignition apparatus, so that when the boat gets over to a certain angle the engine stops. Before she is sent to her station this is thoroughly tested by upsetting the boat, and the engine is immediately started again to see

that everything connected with it is all right.

In the case of boats kept ashore and launched from slipways there is another matter requiring attention irrespective of type. When going on service the crew are all on board in their places before the boat is launched down the slip. It is also necessary to start the engine before launching as it would be extremely difficult, if not impossible in some cases, to do so immediately she had gone into the water. There must, therefore, be sufficient circulating water on board the boat herself to allow the engine to run for a few minutes while on the slip. This is accomplished by having a small water tank for the purpose in the hold of the boat, and when she goes into the water the circulating system is automatically or otherwise turned on to draw from the sea. Or the water may be cooled by a condenser arrangement.

The engine itself is subject to a number of limitations. It must be kept low, so that the casing over it will in no way interfere with the working of the sails and other gear. Weight also is of particular consideration, because the draught of these boats, and consequently their displacement, is limited. Most lifeboats carry water ballast in water-tight compartments below deck, but in the motor boats this water ballast has to be dispensed with, the engine and gear taking its place. In boats which have heavy keels, without any water ballast, the keel has to be reduced on account of the machinery, so that she may carry her weights. Four-cylinder engines of the four-cycle type, running as slow as possible—from 600 to 800 revolutions per minute—and developing as much as 40 brake horse-power, have already been tried in the larger boats. As the engine is only auxiliary, this is a considerable power, and gives a speed of about 7 knots per hour, which is sufficient. These lifeboats having to stand very severe stresses, the engine seating is made particularly strong. Stout bearers are run fore and aft more than half the length of the boat, and are securely tied together. The vibration at full speed is wonderfully slight, probably owing to the position of the propeller, as well as to the form and construction of the boat. The tunnel and deadwood also seem to have little or no effect on the efficiency of the propeller. Governors are necessary on the engines to prevent racing, and in actual service they have acted in a satisfactory manner.

The starting gear is placed at the fore end of the engine, the spindle for the handle or lever coming through the casing in a water-tight gland. The reversing gear is controlled by a horizontal wheel placed on deck, just aft of the casing, and the engine throttle, ignition, and other gear, are all brought up inside the wheel standard, and actuated by water-tight handles. Everything is placed so as to be under the convenient control of the man in charge of the reversing wheel. Solid propellers and reversing blade propellers have both been tried. Two fuel tanks are placed under deck forward, and the engine is supplied by the pressure feed system, a small auxiliary tank placed inside the casing preserving a steady flow of gasoline to the carbureter. The lubrication of the engine is a most important matter. It is, therefore, advisable to have a forced supply to all the main bearings, as the engines require to run continuously without attention, and are inclosed in so small a space. Sail may also be set while the engine is running, and the boat consequently has a considerable inclination, which makes this system of lubrication necessary. The engine has also to run while the boat is on the slipway at a large inclination fore and aft. A bilge pump is fitted on the engine to draw from the engine compartment and the hold. There are at present seven motor lifeboats on the coast, three of which are tunnel boats, the others being old boats converted. These three boats were specially designed and built.

The accompanying engravings show the latest design of a self-righting motor lifeboat of the following dimensions. Diagrams are also shown of midship and through tunnel at propeller sections.

Length over all	40 ft.
Length on waterline	38 ft. 4 in.
Breadth, exclusive of belting	10 ft. 6 in.
Depth	5 ft.
Draught, mean, in service condition	3 ft. 2 in.
Displacement in service condition	13¼ tons
Iron keel	2 tons
Diameter of propeller	22 in.
Brake horse-power	40

THE CINEMATOGRAPH AND ITS DEVELOPMENT.

INVENTIONS IN MOVING PICTURES.

The so-called "picture theater" had already become firmly established in public favor in the United States before it attracted much attention in this country, but the facts that the London County Council have just been called upon to grant 87 new electric theater licenses, and that already some 5,000 of these displays are in operation in different parts of the kingdom, are sufficient to indicate the position that the cinematograph has now attained in public estimation. Recent scientific developments would appear to render it certain that the time is not far distant when the world's important events, or such of them as take the public fancy most vividly, will be represented on the screens of the cinematograph theater within a few hours, or at the most a few days, of their occurrence. We already read of the display of the race for the Derby on the same evening on the stage of a London music hall, and, with certain improvements now promised, we may anticipate that the period is approaching when we shall be enabled to witness events which have taken place at great distances depicted with actual fidelity and even in their true colors after the briefest possible interval of time. It is important to bear in mind that, though this form of entertainment is still in its infancy, the cinematograph is not a mere means of amusement and recreation, but that it is destined to become a most valuable vehicle of instruction, and that it will furnish a powerful educational medium in the hands of the teacher and the public lecturer.

The apparatus consists essentially of a lantern furnished with a concentrated source of light and a condensing lens bringing the rays to a focus on the film, which is a narrow strip or ribbon of celluloid, made to travel rapidly forward. The rays of light having passed through the photograph printed on the film are, by means of a further projection-lens, thrown upon a distant screen, whereby a succession of pictures is produced, so as to convey the effect of movement. The transparent film which contains the instantaneous photographic pictures, taken at the rate of about 16 a second, is perforated on both edges to allow of the forward movement being communicated to it. A good film may run to a length of 1,000 feet, and as each picture is ¾ inch high by 1 inch wide, there may be 16,000 photographs on a single film. The movement of this film is imparted step by step, by a simple arrangement of gearing, and it is so contrived that the change from one picture to the next occupies but one-fifth of the time that the film remains stationary and exposed. During the interval needed for changing the picture the projected image must be entirely cut off from the screen. This is secured by means of a revolving shutter or disk, with a perforation occupying four-fifths of the circumference; the solid portion of one-fifth serving as a stop. It is the short duration of the picture on the screen, followed by a rapid but complete cutting off of the image and light, which gives rise to the objectionable vibration or "flicker" of the pictures shown by these machines.

In order to secure faithful and really lifelike pictures it is essential that the speed with which the scene on the film is passed before the eye should approximate as closely as possible to the time intervals between the photographs, but this, in the existing form of the apparatus, presents serious difficulties. To reduce the flicker, which occasions much discomfort, and even in some cases intense headache, it is customary to drive the machines so rapidly as to change the pictures at a much greater speed than that at which they were originally produced. The effect is to give an unreal and hurried appearance when the scene is one taken from actual life; the movements are intensified into gesticulations, and much of the action is changed into burlesque. Moreover, the rapidity of the motion causes undue wear and tear and damage to the films. Among the expedients which have been adopted with a fair amount of success to overcome the flicker is the use of a piece of violet glass or wire gauze, inserted in the center of the opening in the revolving shutter, exactly opposite to the dark part and equal to it in area. This tends to reduce the periodicity of the flicker, but it is obvious that it must also cut off a good deal of the light. It is, moreover, compulsory on the Continent, though not insisted upon in this country, to interpose a water tank between the light and the film, which must also give rise to some loss of illumination. In the absence of the tank safety is attained by the use of an automatic device, so that, in the event of a stop, the light is cut off from the film. This is known as an "automatic cut-out," and is in general use with English machines. The films are, as already stated, formed of celluloid, and to avoid the danger of fire it has been ordered that before and after passing the lens they must be entirely incased in an iron box.

A recent improvement is embodied in the "dioptic cinematograph," in which two projection-lenses converging upon a common center, are used simultaneously, with two identical films, illuminated by preference from a single source of light. The shutters in this form of apparatus are so contrived that as the image projected from one lens is being cut off, in order to permit the change of picture to take place, the image projected from the other lens is being exhibited. In this way not only is the illumination of the screen at all periods absolutely equal and uniform, but also the images in course of being projected on the screen dissolve one into the other without any obscuration or flicker. An advantage of this system is that the instrument can be worked at the slowest speed and yet project pictures continuously, without creating flicker. In the ordinary single-lens machine it is difficult to synchronize the motion with the gramophone. This difficulty is chiefly due to the speed of working needed to reduce flicker, and has led to the disuse of "singing pictures" in many theaters. But with the dioptic cinematograph it can be overcome.—London Times Engineering Supplement.

MAGNETIC ALLOYS FORMED FROM NON-MAGNETIC MATERIALS.

Before the Institute of Metals, Mr. A. D. Ross stated that magnetic tests had been carried out by him on the ternary magnetic alloys of copper-manganese with aluminium, tin, antimony, and bismuth, and on the binary alloys copper-manganese, copper-aluminium, manganese-antimony, and manganese-boron, more particularly as regards the effects produced by varying thermal treatment. The magnetic quality of the majority of these bronzes is improved if they are heated for some time at 150 to 200 deg. C. In the case of the aluminium and tin ternary alloys, cooling to — 190 deg. C. considerably increases the magnetic susceptibility. Quenching the copper-manganese-aluminium alloys renders them less magnetic, but greatly reduces hysteresis. In the case of an alloy containing 62 per cent of copper, 25 of manganese, and 12.5 of aluminium, the coercive force is reduced to less than 0.3 C. G. S. units upon quenching at 550 deg. C. (that of very soft iron being 1.7), with a permeability nearly equal to that of cobalt. This alloy would be an approximation to the ideal magnetic substance except that it is exceedingly hard and brittle and almost unworkable. Quenching also intensifies the magnetic effect of cooling to — 190 deg. C. Similar results are obtained with the antimony ternary alloy, but in the case of the bismuth alloy the effect of quenching is to increase both the susceptibility and the coercive force. As regards the binary alloys, comparisons are made between manganese-antimony and manganese-boron alloys, but no absolute values of permeability are given. The copper-manganese and copper-aluminium alloys are very feebly magnetic. The author does not support the theory that the ternary alloys contain magnetic compounds, Cu_3Al and Mn_3Al, but adheres to the view that the magnetic properties are due to the formation of solid solutions of which the compound, Cu_3Al, is a constituent. No explanation is offered at present as to why solid solutions of manganese or the compound, Mn_3Al, in the compound Cu_3Al, should add so greatly to the magnetic properties. A similar solid solution hypothesis seems applicable in the case of the copper-manganese-tin alloy, the magnetic compounds present being Mn_4Sn and Mn_2Sn.

Statistics are published illustrating the great progress of Krupp's works for the past year. The figures show that on July 1st the firm employed 68,726 officials, clerks, and workmen, who, with their families, made up the population of a large town; 37,761 were employed in the steel foundry and the gun-testing grounds alone. The coal and coke consumption amounted to 2,491,406 tons. The number of steam engines was 569, developing 89,430 horse-power. The firm has its own electricity works and gas works which latter produced 18,487,300 cubic meters of gas. There are 87 miles of railway, 52 locomotives, and 2,396 wagons.

THE SYSTEMATIC MOTIONS OF THE STARS.*

A SUMMARY OF STUDIES OF THE SUBJECT.

A systematic character in the proper motions of stars was discovered by Herschel, and accounted for by the motion of the solar system in space. Herschel's conclusions were for a time disputed by Bessel, but were confirmed by Argelander, and have since been generally accepted. In the last quarter of a century many determinations of the direction of the solar motion have been made, but the results have not shown that accordance which might have been anticipated. Particularly noticeable are the different results obtained from the proper motions determined by Auwers of the stars observed by Bradley in 1750, and re-observed about 1860, according to the method employed. Applied to these stars, the mathematical methods of attacking the problem developed by Airy and Argelander place the solar apex, or point to which the sun is moving, in declination +35 deg. or thereabouts, while Bessel's method places it at —5 deg. In 1895, Dr. Kobold directed attention to these discrepancies, which seem to point to an error in the fundamental hypothesis underlying these methods of determining the direction of the solar motion. These methods are based on the assumption that the "peculiar" motions of the stars are haphazard, and have no preference for any particular direction or directions in space.

As an outcome of prolonged study of the subject, Prof. Kapteyn announced, in 1905, at the meeting of the British Association in South Africa, that this hypothesis was untenable. He used the well-determined proper motions of 2,400 stars extending from the pole to 30 deg. south of the equator given in Auwers-Bradley. Dividing this area of the sky into twenty-eight regions, he determined the directions of the apparent proper motions of the stars in each region, and found that they showed a preference for two special directions and not for one only. When these favored directions for the twenty-eight areas were plotted on a sphere, they were seen to converge

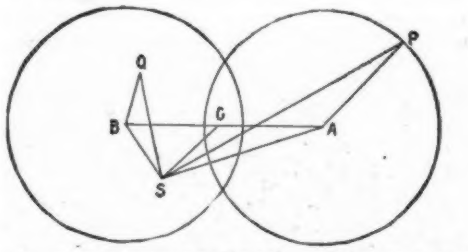


Fig. 1.—VELOCITY DIAGRAM ACCORDING TO EDDINGTON'S HYPOTHESIS.

to two points. Convergence to a point on the sphere indicates that the apparent linear motions of the stars are parallel, just as the radiant point of a meteor stream indicates the direction in which the meteors are all apparently traveling. Relatively to the sun, therefore, the stars are moving in two streams, inclined at a considerable angle to one another; these motions are apparent only, and, when the solar motion is subtracted, are resolvable into two streams moving in diametrically opposite directions, relatively to the center of gravity of the stars. Kapteyn showed that the stars were equally distributed among the two streams, and that their relative motion was in a line in the plane of the Milky Way, directed toward the star ξ Orionis (R.A. 91 deg., decl. +13 deg.) and the opposite direction. The apparent motions of the stars are thus resolvable into a combination of (1) a haphazard motion, (2) the reversed solar motion relative to the center of gravity of the stars, and (3) the stream movement in the direction of ξ Orionis and the opposite direction. It was pointed out by Kapteyn that the determinations of the solar motion made by Airy's method, the one most generally adopted by astronomers on account of its simplicity and convenience, were not much in error, in spite of the systematic character of the motion of the stars in these two streams. For the equations which result from Airy's method agree closely with those of a valuable method of determining the solar motion due to Bravais, which does not assume the haphazard character of the peculiar motions of the stars. But an entirely new fact in stellar astronomy has been elicited in the discovery of the systematic movements toward and away from ξ Orionis.

Mr. Eddington introduced a precise mathematical definition in place of the somewhat nebulous phrase star-stream. A "drift of stars" is defined as a group of stars the velocities of which relative to some system of axes are quite haphazard. The velocity of the "drift" is the velocity of the system of axes, while the "peculiar" velocity of a star is its haphazard velocity relative to the system of axes. Haphazard is defined as a distribution of velocities, according to Maxwell's law for the molecules of a gas. Formulæ are then developed to give the distribution of the directions of proper motions in any small area of the sky which would arise from the projection on the face of the sky of a star drift with a given mean peculiar velocity and a "drift" velocity given in magnitude and direction. Mr. Eddington applied his method to the consideration of the proper motions in Groombridge's catalogue, recently determined at Greenwich by Messrs. Dyson and Thackeray. The catalogue contains about 4,500 stars within 52 deg. of the North Pole, a large proportion being between magnitudes 7 and 9. Comparing the actual distribution with a theoretical one, based on the assumption that the stars form two drifts, he found close accordance. The stars were equally divided between two "drifts" the apparent directions of which were in good agreement with Kapteyn's results. The two streams did not show any distinctive features, each contained bright and faint stars, and stars of all types of spectrum, and, further, the mean distances from the sun of the stars contained in the two "drifts" were the same. Additional confirmation was obtained from 1,200 stars within 10 deg. of the North Pole, the proper motions of which had been determined by comparison of the Greenwich positions in 1900 with those found by Carrington in 1855. In a later paper, and by a somewhat different method, about 2,000 fairly bright zodiacal stars were examined.

According to Mr. Eddington's determination, the velocity of one stream relatively to the sun may be represented by *SA*, and that of the other by *SB*, while the haphazard velocities of the stars composing the streams are equally in all directions from the centers *A* and *B*, and their mean values are represented by the radii of the two spheres. The solar velocity relative to the center of gravity of all the stars is represented by *SG*, and the rates at which the streams are separating by *AB*. If *SP* denote the velocity of one star relatively to the sun, this may be analyzed into *SA*, the "drift" velocity, and *AP*, the "peculiar" velocity (which in this instance has its mean value); the drift velocity *SA* may be analyzed into *SG*, the solar motion, and *GA*, the velocity of the stream. Similarly, *SQ*, the velocity of another star, may be resolved into a component of the second stream, the peculiar velocity of which is *BQ*, or only half the mean value.

Prof. Schwarzschild assumes that the "peculiar" motions of the stars do not obey Maxwell's law, but a slightly modified law in which the resolved parts of the velocities in one direction are all increased in a definite proportion, thus giving a spheroidal instead of a spherical distribution. When combined with the solar motion, this distribution of "peculiar" velocities gives two favored directions for the proper motions of the stars included in any small area of the sky, and has the advantage of representing the stars as a single instead of a dual system. Applied to the Greenwich-Groombridge proper motions, the assumption shows a very satisfactory accordance with facts. According to Prof. Schwarzschild, the observed proper motions of these stars would be produced by a velocity of the solar system *SG* and "peculiar" velocities of the stars the mean values of which in different directions are radii of the prolate spheroid *ABA'B'*. Thus the velocity *SQ* of a star is resolvable into *SG*, the solar motion, and *GQ*, the "peculiar" velocity. In this instance the "peculiar" velocity is one-half the mean "peculiar" velocity belonging to the direction *GQ*. In his second paper Prof. Schwarzschild develops his theory with great mathematical elegance so as to make it applicable to cases where the number of stars per unit area is small. In this form it is applied by Mr. Beljawsky to the stars of large proper motion in Prof. Porter's catalogues, although its application is not free from objection, as these stars were selected on account of their large proper motion, while the method is strictly only applicable to unselected proper motions.

Prof. Dyson collected all the proper motions greater than 20 seconds a century from various sources, and by a simple graphical method determined the favored directions of motion. Partly owing to the small effect of accidental error of observation on the direction of the proper motion of these stars, and partly because only large proper motions were considered, the two apparent star streams were shown with great clearness. In the large majority of cases it was possible to assign individual stars to one or other of the two streams, and thus a verification was obtained of the result that the two streams showed no difference as regards the magnitude or type of spectrum of the stars in them. Of 1,800 stars examined, 1,100 belonged to the first stream, 600 to the second, and the remaining 100, which could not be assigned to either, showed no motion of a systematic character. The large proportion of stars belonging to the first stream arises from the mode of selection according to the magnitude of proper motion. Kapteyn's and Eddington's result, that when stars are taken without selection they are equally divided between the two streams, is used to determine the ratio of the stream velocities. When this is determined the apparent movement in two streams, as seen from the earth, is replaced by the solar motion and two streams moving in opposite directions relative to their center of gravity.

There is at first sight considerable difference between Kapteyn's description (followed by Eddington and Dyson) of the systematic movements of the stars, and that of Schwarzschild. The dual character of Kapteyn's system should not be unduly emphasized. Division of the stars into two groups was incidental to the analysis employed, but the essential result is the increase of the peculiar velocities of stars toward one special direction and its opposite. It is this same feature, and not the spheroidal character of the distribution, which is the essential of Schwarzschild's representation. The results obtained by the two methods agree very closely. Defining the "apex" as the direction of the sun's motion relative to the center of gravity of the stars, and the "vertex" as the direction of motion of one stream relatively to the other (Kap-

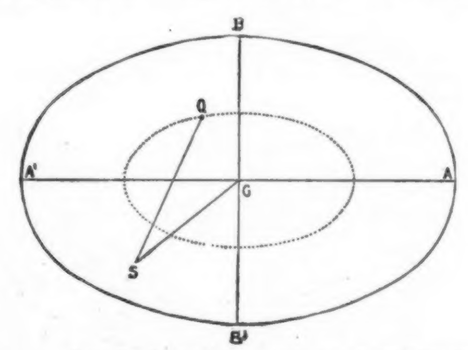


Fig. 2.—VELOCITY DIAGRAM ACCORDING TO SCHWARZSCHILD'S HYPOTHESIS.

teyn) or the major axis of Schwarzschild's spheroid, the accordance of the different results is shown in the following table:

	Apex R.A. Dec. Deg.	Vertex R.A. Dec. Deg.
Kapteyn—Bradley stars	—	91 + 13
Eddington—Groombridge stars	266 + 31	95 + 3
Schwarzschild—Groombridge stars ...	266 + 33	93 + 6
Dyson—Stars of large proper motion..	281 + 42	88 + 24
Beljawsky—Porter's stars	281 + 36	86 + 24
Eddington—Zodiacal stars	—	109 + 6

It may be noticed that the Groombridge stars gave almost identical results by the methods of Eddington and Schwarzschild, and that Beljawsky and Dyson, whose material was very similar, obtained results in close accord.

Although attention may be directed to Kapteyn's observation that the vertex lies in the plane of the Milky Way, it is too soon to offer any explanation of these remarkable movements of the stars. To have disentangled them from the irregular proper motions of the stars is itself a very important step. By clearing up the difficulty in the anomalous results previously found for the direction of the solar motion and by the discovery of systematic movements in which all the stars share, Prof. Kapteyn has made the most important contribution to this branch of astronomy since the time of Herschel.—Nature.

* (1) J. C. Kapteyn, Reports of the British Association for the Advancement of Science, 1905, p. 257.
(2) A. S. Eddington, Monthly Notices of the Royal Astronomical Society, 1906, vol. lxvii., p. 34, and vol. lxviii., pp. 104 and 588.
(3) K. Schwarzschild, Nachrichten von der Königlichen Gesellschaft der Wissenschaften zu Göttingen, 1907, p. 614, and February, 1908.
(4) S. Beljawsky, Astronomische Nachrichten, Band clxxix, p. 293.
(5) F. W. Dyson, Proceedings of the Royal Society of Edinburgh, 1908, vol. xxviii., part i., p. 231; 1909, vol. xxix., part iv., p. 376.

Owing to the salt-laden atmosphere of Charleston, S. C., the ordinary form of grid resistance of asbestos and iron ribbon cannot be used because they corrode rapidly and split open. The Charleston Consolidated Railway and Lighting Company is therefore using three suspension spiral resistances which are mounted on micanite bars fitted with intermediary micanite washers. Another unusual maintenance feature on the lines of the Charleston Consolidated Railway and Lighting Company is the repairing of worn Stanwood car steps by covering them with lead tread.

FIRST NORWEGIAN ELECTRIC STEEL WORKS.

AN INTERESTING APPLICATION OF THE HIORTH SYSTEM.

BY DR. ALFRED GRADENWITZ.

It is well known that the Kjellin furnace only lends itself for the melting of relatively small quantities of pure materials, and for the making of steel without refining.

In order, in fact, to increase the charge of this type of furnace, both its diameter and its cross-section would have to be augmented. When augmenting only the cross-section, the electrical resistance would not be sufficient to obtain the required working temperature, while on increasing the diameter the distances between the primary and the secondary windings and the magnet core are likewise augmented in proportion, thus increasing excessively the losses due to dispersion.

These difficulties have been first overcome in Germany by Röchling and Rodenhauser in connection with whose furnace—comprising special windings for heating the iron—any dispersion losses are avoided by arranging secondary windings round both magnet arms.

By a strange coincidence, the same fundamental idea was patented in Norway by Albert Hiorth of Christiania, just one day before the issue of the German Röchling-Rodenhauser patent, the main difference between the two furnaces being that while in connection with the Röchling-Rodenhauser arrangement the special current used for heating the working and slag chambers is supplied to the molten iron, Hiorth prefers to supply this current to the slag layer, so as to combine the advantages of induction and electrode furnaces. In fact, electrode furnaces are known to be especially suitable for the refining of charges on account of the particularly strong slag effects, whereas on the other hand induction currents are most advantageous for the heating of iron masses.

The first Norwegian steel works operated on the Hiorth system has been recently installed on the Jössingfjord, near Sogndal, and deserves especial interest because of all the parts of the plant having been supplied by Norwegian firms (the electrical equipment by Norsk Elektrisk & Brown Boveri A. S.).

PART VIEW OF MASONRY DAM AT JÖSSINGFJORD.

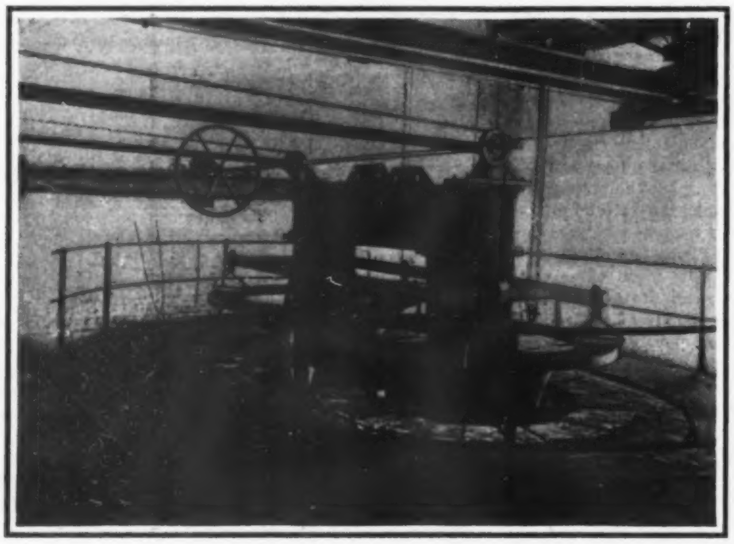
After obtaining valuable results in regard to the refractory lining by the experimental operation of the first furnace, a larger tilting furnace was installed, which both from an electrical and a metallurgical point of view is giving complete satisfaction, yielding with a perfectly quiet melting bath, in ordinary operation, power factors as high as 0.75 and 0.8, and even higher figures (up to 0.84).

The design of this furnace is represented schematically in Fig. 1. *A* surrounds the two ring-shaped melting chambers; *B* is the magnet, and *C* a partition. *DD* are electrodes arranged to the left and right of this partition, and which can be connected together by the winding *F*, which in accordance with the figure surrounds the magnet *D*. *G* is the primary winding of the dynamo.

When connecting the electrodes *DD* by the conductor *F*, the furnace can be run as an electrode furnace.

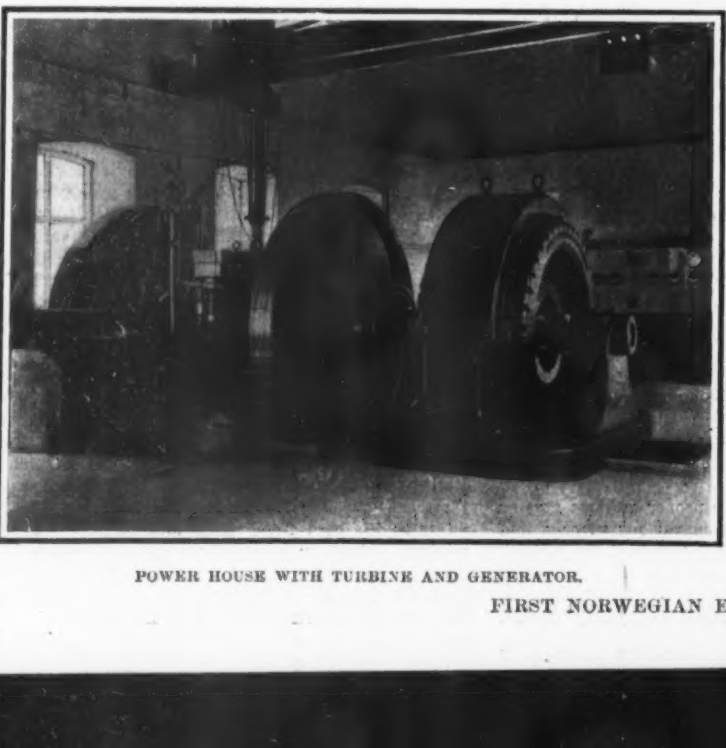
The partition *C* can be perforated or made so low that the slags, and possibly part of the metal, will flow over it. Instead of a single partition, two or more partitions can be used. When choosing the partition (or partitions) sufficiently low for part of the liquid matter to flow over it, one or more intensely heated zones are obtained, to which the raw material should be preferably supplied.

If the melting chamber is to be especially long, the magnet core is hollowed out in the portion traversing the furnace, which imparts a greater circumference to the iron mass, and causes it to lie more closely to the melting chamber. This arrangement is intended for

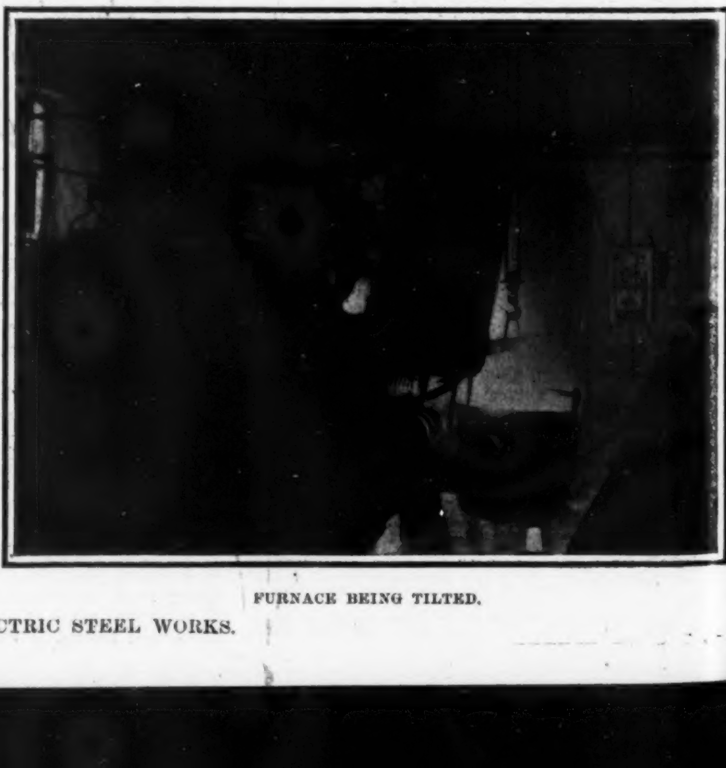


TILTING FURNACE SEEN FROM THE TOP.

ELECTRIC STEEL WORKS AT JÖSSINGFJORD.

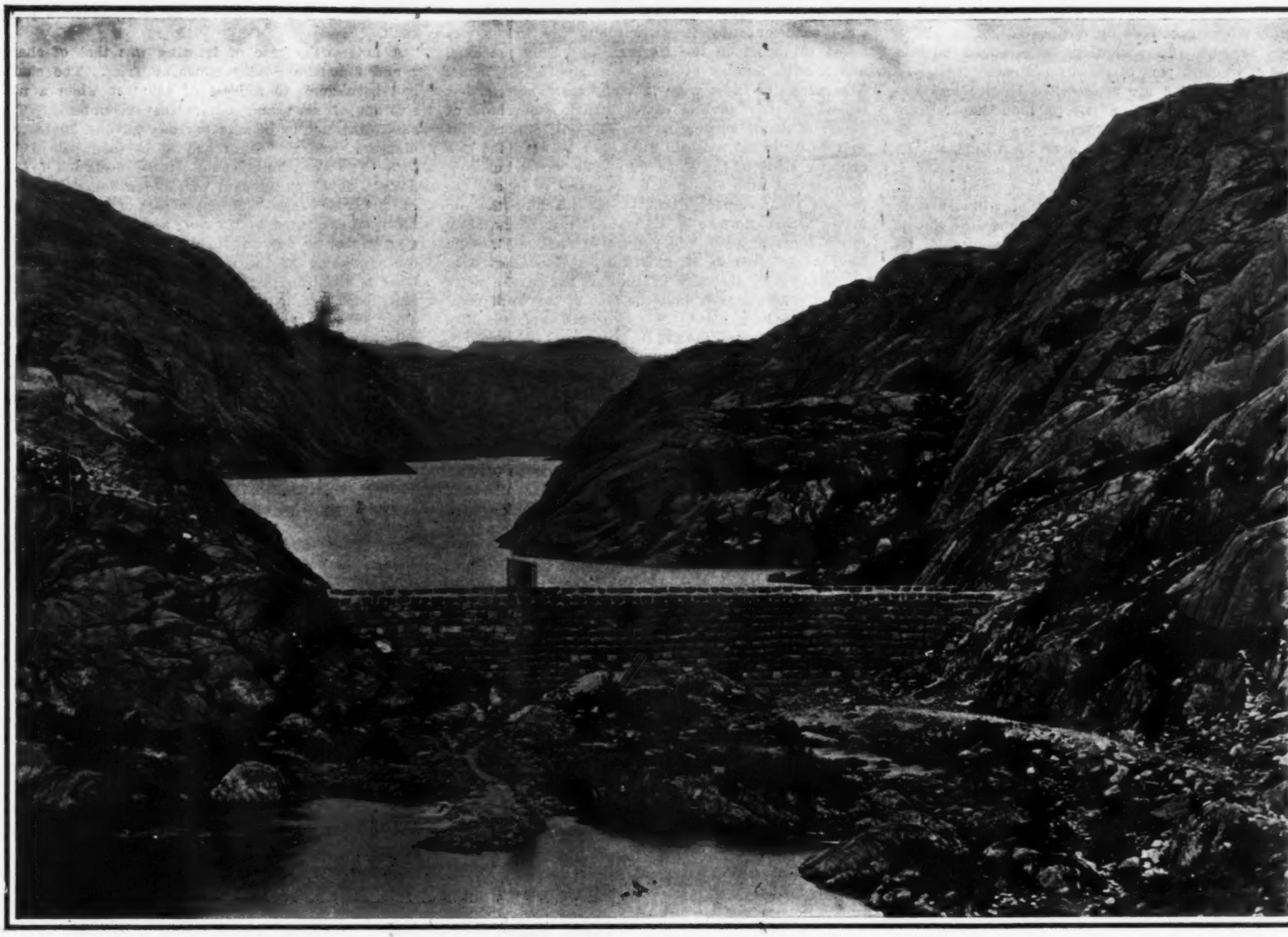


POWER HOUSE WITH TURBINE AND GENERATOR.



FURNACE BEING TILTED.

FIRST NORWEGIAN ELECTRIC STEEL WORKS.



GENERAL VIEW OF MASONRY DAM AT JÖSSINGFJORD, NORWAY.

VIEW OF JÖSSINGFJORD AND ITS ELECTRICAL STEEL WORKS.

FIRST NORWEGIAN ELECTRIC STEEL WORKS.

reducing the dispersion losses, and at the same time cooling the magnet core by the passage of an air or water current. The winding is arranged outside round the hollow part of the magnet core.

In Figs. 2 and 3 are represented longitudinal and transversal sections of a Hiorth induction furnace designed on the disk transformer system. The primary winding is distributed over four (and in the case of single-phase current even more) coils *b* and *c*, each of which is arranged round a vertical part of the iron core, so that one coil is situated immediately below, and another coil immediately above the charge in the ring-shaped furnace chambers connected together in the middle of *E*. This is intended for insuring a distribution as favorable as possible of the copper and iron masses of the transformer, and a maximum efficiency with dispersion losses as small as possible. The individual windings of the coils situated below the melting chamber are preferably designed as water-cooled pipes, or are cooled with an air current. The upper coils are preferably so designed that they may be lifted for repairs.

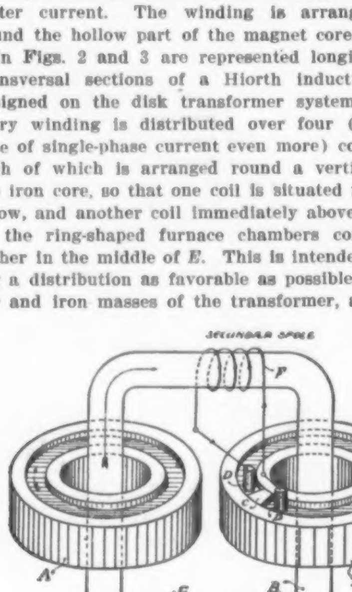


FIG. 1.—SCHEMATIC DESIGN OF TILTING FURNACE.

By widening the melting chamber with *E*, the working space required is obtained where any metallurgical operations (charging, treating the slag, etc.) are carried out unimpeded by the primary windings.

The use of the disk transformer system is intended for obtaining, without any prejudice to the efficiency of the furnace, a sufficiently large space between the vertical parts of the iron core and the furnace wall for the furnace being tilted sufficiently during the discharging, independently of the iron core. In the case of polyphase current, both the diameter and the cross-section of the melting bath can be increased very considerably, with a view to augment the capacity of the furnace, as the primary as it were follows the secondary circuit.

By combining the two types of furnace represented in Figs. 1 and 2 respectively, that is, by arranging auxiliary electrodes *D* in the furnace chamber *E*, between the two secondary rings, the inventor has endeavored to combine the advantages of a pure induction furnace with those of an arc furnace.

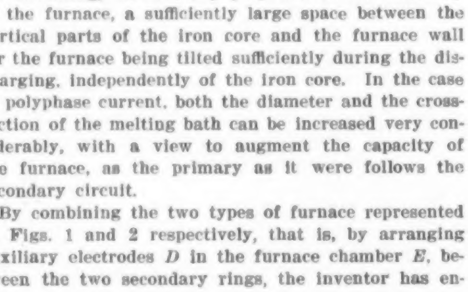


FIG. 2.—LONGITUDINAL SECTION OF INDUCTION FURNACE DESIGNED ON DISK TRANSFORMER SYSTEM.

The tilting induction furnace installed at Jössingfjord is intended for charges of five to six tons, and has been in operation since December, 1909.

THE CUTTING POWER OF FILES.

PROF. W. RIPPER, D.Eng., M.Inst.C.E., before the British Association for the Advancement of Science, in his address, said he was not aware of the existence, until recently, of any method of testing the cutting power of files, except by handing the files to skilled workmen and obtaining their reports upon them. This method is obviously open to grave objections, but a few years ago the Herbert file-testing machine was introduced, and, as a result, files are now required to reach a certain standard of cutting power. A description of this machine with illustrations was given. Unfortunately, very early in the history of the machine, doubts were entertained as to the accuracy of the results obtained by it, as files known to be good were condemned by it. Eventually the writer was asked to report on the Herbert file-testing machine, and a large number of tests were accordingly made. The results of these were in many cases normal, but in others they showed extraordinary differences of effectiveness of cutting power, not only among files said to be in all respects alike, but between the two opposite sides of the same file. The writer reported that the machine appeared to be defective in one important point—namely, that in the machine the file moves across the face of the test-bar through an absolutely constant path, the respective teeth of the file each stroke working in identically the same grooves or furrows on the face of the test-bar stroke after stroke. The result is that the face of the work occasionally becomes glazed in appearance, and the files cease to cut, though the file itself may not be worn out. In the case of hand-filing, no two strokes are made in exactly the same direction. The conditions, therefore, under which the tests are made in the machine differ from those under which the file is worked in actual practice, and this difference works, at least in some cases, to the disadvantage of the file. For the purpose of removing this objection, the writer has devised an addition to the Herbert machine, by means of which the path of the file in the machine is no longer a constant one, but changes its direction stroke by stroke, as in the case of hand-filing. To secure this, the file is no longer held rigidly at its two ends, but is connected by ball-joints, the effect of which is equivalent to that of a wrist movement at each end of the file. The variation of the path of the file each stroke is obtained by slightly shifting the position of one end of the file, relatively to the other end, by a simple mechanism during each return stroke, so that on the following working stroke it moves in a different path from that which it had in the preceding stroke. The means by which this movement is obtained were explained and illustrated by diagrams. The addition of this arrangement to the Herbert file-testing machine has resulted in the removal to a large extent of the irregular results previously obtained from files of similar quality.

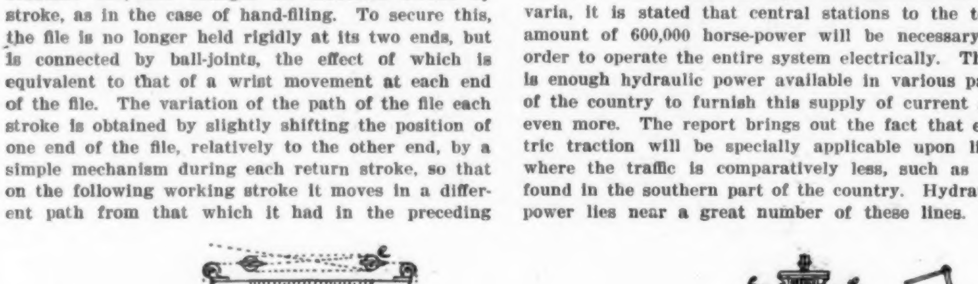


FIG. 3.—TRANSVERSAL SECTION OF HIORTH'S INDUCTION FURNACE.

FREEZING THE EARTH.

IN 1883 Poetsch sank the first shaft by the freezing method. The process is fairly well known. It consists briefly in boring a number of holes within a large circle around the future shaft, sinking pipes, and connecting them on the surface in a collective ring. The lowest pipe has a bottom and the pipes are about 3 feet apart, and set in a circle from 10 to 14 feet greater in diameter than the final shaft. The rest of the process is that of any refrigerating plant. A salt or magnesium chlorate solution is cooled to 15 deg. or 20 deg. and is circulated in the pipes under pressure by means of compressors and pumps. In this way the latent heat of the earth around the proposed shaft is drawn away and a solid mass of frozen material is obtained, after which the shaft sinking may be begun.

In recent years the freezing system has made wonderful strides, and sinking of shafts of 1,100 and 1,300 feet in sand bottom is nothing unusual. The fear that freezing beyond a depth of 650 feet would have to be made by the section system, owing to the deviation of pipes from the perpendicular when reaching greater depths, has been eliminated. Two instruments are now in use that give the deviation in fractions of an inch.

The principles of the Erlungenhagen and the Gebhardt plumb line apparatus are the same. Both have balanced pendulums, which are guided in the one case by an electric current and in the other case by clockwork, and both of which mark points on a strip of paper passing them mechanically. By watching the position of these points the changes from the perpendicular can be determined. Electro-magnets at the sides of the instruments, and a clockwork in the other case, prevent the pendulums from running out of position. When a marked change of the pipe position is noted auxiliary holes have to be bored and new pipes sunk.

A noteworthy case of freezing was that of shafts 1 and 2 in the Baldur mines at Trier. The shafts had been sunk to a level of 445 feet when a new stratum of sand and water was encountered. The shaft was not to be any narrower, being 20 feet in diameter, and the depth had to be extended to 560 feet. The bore holes could not be deepened to the desired depth on account of the low temperature of the upper 445 feet. The upper part of the shaft, having been excavated to 383 feet, was now widened to a diameter of 23 feet and to a depth of 435 feet under the protection of the frozen earth. At the 435-foot level a cast-iron plate 23 feet in diameter, with 26 holes cast into it, each of them slanting toward the outer part of the circle, was lowered. Joining these holes, twenty-three flanged sockets 10 feet long having the same slant were flanged to the plate, and the entire new set of flanges concreted almost to the top, leading to the surface of the shaft. The slant outward caused extension of the freezing pipe circle, which returned to the perpendicular through gravitational forces.—Mining World.

ELECTRIC RAILWAYS.

ACCORDING to an official report concerning the application of electric traction upon the railroads in Bavaria, it is stated that central stations to the total amount of 600,000 horse-power will be necessary in order to operate the entire system electrically. There is enough hydraulic power available in various parts of the country to furnish this supply of current and even more. The report brings out the fact that electric traction will be specially applicable upon lines where the traffic is comparatively less, such as are found in the southern part of the country. Hydraulic power lies near a great number of these lines. As concerns the northern part of Bavaria, electric traction would not give an economical advantage except upon lines presenting a traffic which is twice the figure of the southern railroads. It is intended to make the first move in this direction upon the three lines Salzburg-Berchtesgaden, Garmisch-Griesen and Garmisch-Scharnik, and the single-phase electric system has been decided upon in this case. The present project includes the running of high-speed express trains.

It has been proposed at various times to utilize the principles of wireless telegraph apparatus in order to observe atmospheric discharges during storms and to obtain a record of these by a registering device. Following the earlier researches of Popoff and others with the coherer and the bolometer device of M. Tissot, more recently M. Paul Jegou of Paris brings out a new method in which he employs the electrolytic detector in order to secure its well known advantages. He uses the detector combined with a Wheatstone bridge containing very fine platinum wire which can be very well protected from atmospheric influence, and this makes it more reliable than the bolometer which is easily disturbed. A swinging coil gavanometer of the Deprez-D'Arsonval type serves as the indicator and the spot of light is received on a photographic recording device having a moving band. Such an apparatus has been set up. In a cabin is placed the detector and battery, making connection to an antenna and a ground wire. Two wires lead from the detector to the galvanometer which is placed in a dark chamber some 600 feet off. A beam of light from the galvanometer mirror is reflected upon a Richard photographic register, and this latter is designed so that the band will be fed out at three different speeds in order to observe the effect of the storms in greater or less detail. At the same time we can use telephones upon the circuit without disturbing the action, and at each discharge the characteristic crackling sound is heard in the telephone. Should the storm become dangerous, a switch allows of connecting the antenna directly with the ground, and lightning arresters also give protection to the apparatus.

THE ZEEMAN EFFECT.

A SIMPLE EXPLANATION.

IN the year 1896 the Dutch physicist Zeeman discovered that the two yellow lines, into which the light of a Bunsen flame colored by sodium is resolved by the spectroscope, became broader when the flame was placed between the poles of a powerful electromagnet, and resumed their normal width when the current which energized the magnet was turned off. The following analysis is based, not on the sodium lines, but on the blue-green cadmium line, which shows the Zeeman effect very clearly, when examined with specially devised apparatus.

In Fig. 1, *EF* indicates the direction of the lines of force due to the magnet *NS*, while *AB* and *eD* represent the two directions which are perpendicular to the lines of force, and to each other. If the path of the luminous pencil, coinciding with the axis of the spectroscope, lies along *AB*, *eD*, or any other line at right angles to *EF*, the single spectral line is

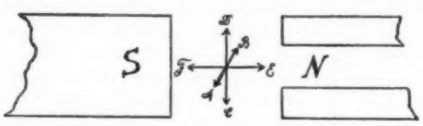


FIG. 1.

replaced by three fainter lines, of which one occupies the position of the original line and the others are at equal distances to right and left. The light of the middle line and that of the lateral lines is found to be polarized in planes perpendicular to each other. When the direction of observation is parallel to *EF*, i. e., to the lines of force, the two lateral lines appear, in the same positions as before, but no middle line is visible. These two lines are circularly polarized in opposite directions. In order to observe this variety of the Zeeman effect one pole of the magnet must be perforated as in Fig. 1.

It would appear impossible to find a simple and complete explanation of these complex phenomena, but such an explanation is easily deduced from the electromagnet theory of light, in conjunction with the electronic theory of the structure of matter. The undulatory theory of light, introduced by Huygens three hundred years ago, assumes that light is propagated in the form of waves through the ether, a hypothetical substance filling all space.

Let the uppermost row of dots in Fig. 2 represent a row of ether particles at rest. If any of these particles is displaced by any cause it will, in consequence of the elasticity of the ether, oscillate like a pendulum about its position of equilibrium. As the first particle moves downward it will, so to speak, drag the second particle down with it, or, rather, after it. The second particle will exert a similar effect upon the third, and so on. Hence the row of particles will assume, after successive equal and very short intervals of time, the forms of the second, third, fourth, and fifth lines of dots in the figure. After four more such intervals the ether particles will occupy the positions indicated in the sixth and lowermost line of dots. Here we see that the depression in the curve has moved to the right and has been succeeded by an elevation. In this manner a series of

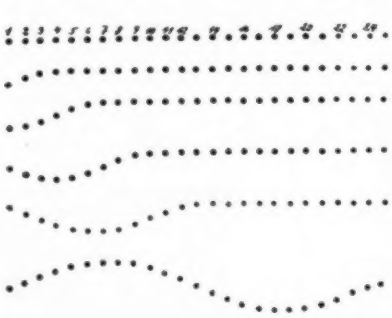


FIG. 2.

alternating elevations and depressions is produced which move forward with a definite velocity, the velocity of light, as long as the first particle continues to oscillate. If the oscillation continues indefinitely the result is a plane-polarized ray of light, in which the oscillations of all the ether particles take place in the plane of the paper, although the plane perpendicular to the paper is called the "plane of polarization." The motion, however, does not continue indefinitely, but dies away after each particle has performed a few oscillations. The next disturbance of the first particle (or any other) may cause oscillation at right angles to the paper, or in any other direction. As, in luminous bodies, thousands of such impulses act upon the ether particles every second, there is no reason why the light of the sun or candle should be polarized in any particular plane. It is possible, however, to produce, by various methods, light polarized in any desired plane. It is possible, also, to produce circularly polarized light, in which the ether particles are assumed to move in circles, like the bob of a conical pendulum, while the wave form, or instantaneous position of the row of particles, is represented by a helix, or screw. (Fig. 3.) There are two varieties of circular polarization, corresponding to the two kinds of screws, right-handed and left-handed.

Although light has been recognized, for three centuries, as a disturbance propagated from point to point of a medium with finite velocity, it was assumed until about sixty years ago that electric and magnetic forces exert their actions instantaneously at all distances. Faraday's experiments led him to conclude that electric and magnetic forces are propagated with finite velocity through the ether, and to regard the magnetic field as the result of stresses, or disturbances of equilibrium, in that medium. Subsequently, this velocity was measured, by various indirect methods, and was found nearly equal to the velocity of light. This approximate agreement, added to the other evidence, led Maxwell to the belief that light is an electromagnetic disturbance propagated in the form of waves according to electromagnetic laws. Maxwell's electromagnetic theory of light obtained a brilliant experimental confirmation in 1888, when Hertz produced electromagnetic waves by purely electrical methods, and proved that these waves could be reflected, refracted and polarized, according to the laws of optics. In the meantime, both the velocity of light and that of electric disturbance had been remeasured by more accurate methods and had been proved to be substantially identical and very approxi-

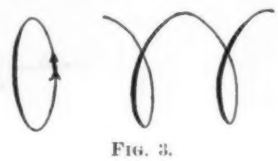


FIG. 3.

mately equal to 300,000 kilometers, or 186,000 miles, per second.

This theory, however, failed to account for chromatic dispersion, i. e., the fact that waves of different length travel with different velocities through transparent substances and, consequently, are spread out into a colored spectrum in cases of oblique incidence. According to Maxwell's theory the index of refraction should be the same for all wave lengths and equal to the specific inductive capacity of the substance.

In the various mathematical theories of dispersion it is assumed that the molecules or atoms of matter are capable of vibration at definite rates and that they are thrown into vibration, more or less strongly, by incident light waves, according as the periodic time of these waves approximates more or less closely to any of the periods which are characteristic of the substance. In the older theories of dispersion it was assumed that the atoms vibrated in some purely mechanical way, but a far more satisfactory explanation of the phenomena of dispersion is given by the new electronic theory of matter, which regards every material atom as a congeries of positive and negative electrons, or atoms of electricity. There is good reason to believe that negative electrons can exist in the free state, in cathode rays and the β rays of radium, for example, but no experimental evidence for the existence of positive atoms, not combined with ponderable matter, has yet been discovered.

Some of the negative electrons of the atoms are assumed to be capable of oscillation or rotation about their positions of equilibrium, in periods which are characteristic of each chemical element. This motion can be induced by electromagnetic waves, including the waves of light, and, conversely, it gives rise to luminous or other electromagnetic waves of the same period in the surrounding ether. The electrons are set into vibration, also, by heating the substance to a high temperature. Hence, when cadmium is heated in a Bunsen flame, the electrons are thrown into vibration and they produce the blue-green light or spectral line which is characteristic of cadmium.

If the cadmium flame is placed between the poles of a powerful magnet, the moving electrons will be subjected to the same forces that would be exerted upon wires carrying electric currents. The electrons are practically infinite in number and are moving in all directions, but the result will be the same if we select any three mutually perpendicular axes and assume that one-third of the electrons are moving parallel to each of these axes.

In Fig. 1, let these axes be represented by *AB*, *eD*, and *EF*, of which *EF* is parallel to the magnetic force. Then, when the magnetic force is not applied, not only will there be millions of electrons vibrating along each of these lines in the same periodic time, but in each of the three groups there will be millions of electrons whose oscillations have the same amplitude and the same phase. The dots close to the line *CD* in Fig. 4 represent two such electrons, the amplitude of their oscillation being *CD*, while its phase, at the moment considered, is represented by the distance

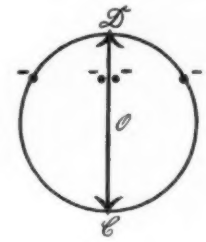


FIG. 4.

of the dots from one end of the swing, say, *D*. Now these two oscillating electrons are equivalent, in their relation to the external magnetic force and in their action on the surrounding ether, to two electrons moving in opposite directions round a circle of diameter *CD*, in a plane perpendicular to the magnetic force and accomplishing one revolution in the time occupied by the original pair of electrons in moving from *D* to *C* and back. In this way all the electrons which oscillate parallel to *CD* can be replaced by an equal number of electrons moving in circles, half of them revolving in each direction. The same reasoning applies to the electrons which oscillate parallel to *AB*. (Fig. 1.) Thus we have replaced the actual system of electrons moving in all directions in space by three equal groups, the electrons of the first group oscillating in straight lines parallel to the magnetic force, those of the second revolving in the direction of the hands of a clock, in circles perpendicular to the magnetic force, and those of the third revolving in similar circles in the opposite direction. (It is probable that the electrons actually revolve in circles or ellipses, so that this artificial system is not only equivalent but very similar to the real system.)

According to the laws of electrodynamics, the electrons which oscillate in straight lines parallel to the magnetic force are not affected by that force, but the orbits of the electrons which revolve in planes perpendicular to the magnetic force are expanded or contracted, according to the direction in which they revolve. As in the case of a planet, the periodic time increases and diminishes with the size of the

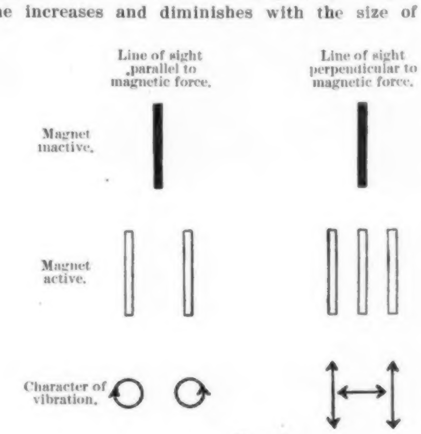


FIG. 5.

orbit, though not in the same proportion.

Each group of electrons is the source of waves of light, the vibrations of which are similar to its own. In the direction of the magnetic force, therefore, the two groups of revolving electrons produce two beams of circularly polarized light, right-handed and left-handed, one of which has a greater, and the other a smaller, period and wave length than those of the unmagnetized cadmium light, and which consequently appear in the spectroscope as two lines, one on each side of the now vacant position which the single cadmium line occupied before the magnetic force was applied. The electrons which oscillate in straight lines parallel to the magnetic force emit no light

in this direction, for light consists entirely of vibrations transverse to the direction of propagation.

In any direction at right angles to the magnetic force, on the other hand, these oscillating electrons emit plane-polarized light which, as its wave length is not altered by the magnetic force, appears in the spectroscope as a line which has the position of the normal cadmium line, but only one-third of its intensity. When viewed in this direction the revolving electrons present the edges of their orbits to the observer so that, if they could be seen, they would appear to move in straight lines, perpendicular to the line of sight, as well as to the magnetic force. Hence the two groups of electrons, revolving in different periods, produce two spectrum lines, which are slightly displaced from the normal position toward the red and violet ends of the spectrum, respectively, and both of these lateral lines are plane-polarized in a plane at right angles to the plane of polarization of the middle line.

The appearances presented and the character of the luminous vibrations in the two cases are illustrated by Fig. 5.

Extraordinary apparatus is required for the observation of the Zeeman effect in this clear and distinctive form. The spectroscope must have very high resolving power. Diffraction grating and interference spectroscopes are the most effective. The electromagnet must also be very powerful, for the separation of the lines increases with the strength of the magnetic field. Faraday, in 1862, sought vainly for some such effect, and Zeeman, in his first experiments, obtained only a broadening, and not a division, of the sodium lines.—Adapted for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

THE BRIQUETTING OF COAL DUST.

A NOVEL BELGIAN PROCESS.

BY LINDON BATES, JR.

THE increasing consumption of coal, coincident with the exhaustion of certain veins, has for some time made economic the utilization of coal dust throughout Europe; and a considerable industry in the manufacture of this dust and coal debris into briquettes has sprung up in Germany, France, England, and more especially in Belgium, where the use of this fuel has become for some purposes universal. The Belgian government railways use this sort of fuel exclusively, and any one who has traveled on the Brussels and Ostend express will notice the carefully ranked piles of black 5-kilo (11.02 pound) bricks stacked up in the tenders. The coastwise steamers plying to Antwerp largely use a larger size. In the households 1-kilo (2.20 pound) blocks heat the kitchen ovens. On the street corners the coal "eggs" are sold at a few centimes apiece for the braziers of the poor.

In Germany, where the statistics of the industry have been carefully kept, there were by the last figures 52 briquette factories producing 1,550,000 tons. The consumption is given as 635,625 tons for the government railways, 192,110 sold for domestic consumption by dealers, 525,863 consumed by factories and industrial works, 119,400 used on steamers or exported, and 13,132 used on the canals—a total of 1,486,130 tons.

The manufacture of coal tar into briquettes is thus a very considerable industry.

The fundamental principle of the manufacture of briquettes consists in the use of residue tar, warmed so as to be soft and sticky, mixed with the coal dust, and the compound strongly compressed into solid bricks.

The tar residue, called "brai" in the Belgian terminology, comes usually from gas plants or coking furnaces. The coal tar resulting from these processes distills into benzoates, C_6H_6, and C_7H_7, naphthas, etc., leaving as residue this brai, of varying chemical proportions of C, H, and O, and amounting to about 50 per cent of the original tar volume.

There are several tests for the utility of this residue for fuel making, for the wrong variety may give poor results in crumbling or cracking briquettes. The usual empirical test is to chew a piece of it, and if it melts and becomes soft, it is usable. More scientifically, it should soften at 60 deg. to 70 deg. C. (140 deg. to 158 deg. F.), and melt at 90 deg. to 100 deg. C. (194 deg. to 212 deg. F.).

This residue, which sells from $8 to $10 a long ton, is the most expensive constituent. The evolution of briquette manufacture has been toward a type of machine which, by its great compression, will compensate for and allow a low percentage of this relatively expensive agglomerating material. By the most modern system, only 5 to 7 per cent of brai is necessary to make a solid brick out of coal dust.

In preparing for the process, the coal dust is first washed; then thoroughly dried, for any moisture spoils the product. The coal and the brai are now thoroughly ground, mixed in the proper proportion, and carried on to a warming oven. Here the mixture is heated to the melting point of the brai, about 70 deg. C. (158 deg. F.). Next the mixture is dropped down a series of shaking tables, and brought into contact with superheated steam at 275 deg. C. (527

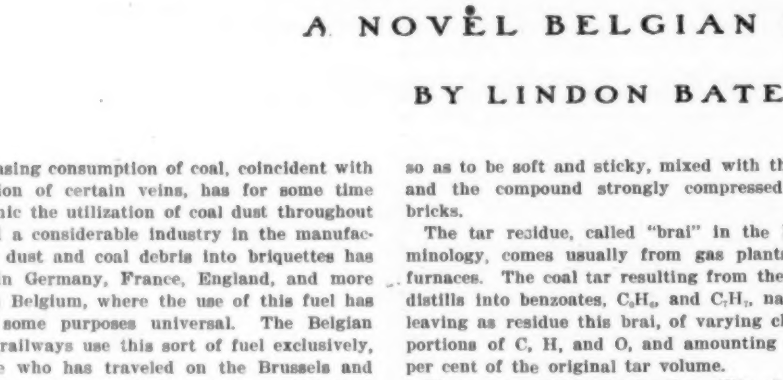


FIG. 2.—VIEW OF MACHINE PLAN.

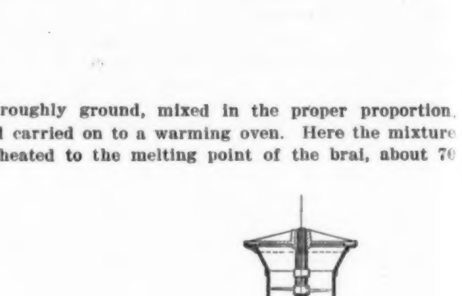


FIG. 5.—ARRANGEMENT OF BRIQUETTING PRESS PROVIDED WITH KNEADING MECHANISM. LONGITUDINAL SECTION.

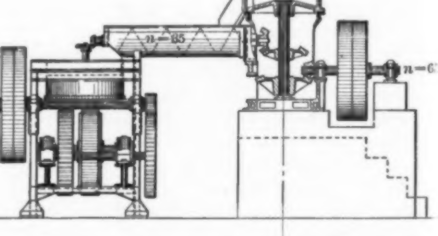


FIG. 5A.—TOP PLAN VIEW OF MACHINE IN FIG. 5.

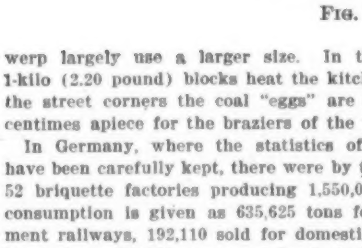


FIG. 3.—VERTICAL SECTION THROUGH *a b* (FIG. 1).

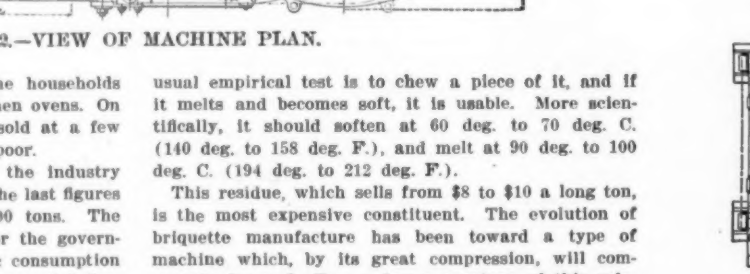


FIG. 1.—THE VEILLON SYSTEM OF MANUFACTURING BRIQUETTES. MACHINE FOR COHERING COAL DUST AND BRAI INTO MASS.

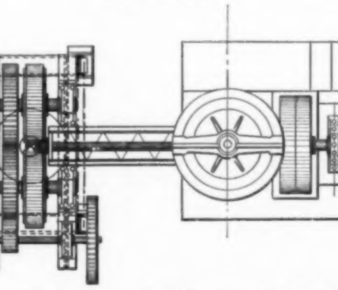


FIG. 4.—VERTICAL SECTION THROUGH *c d* (FIG. 1).

deg. F.) to take out any moisture that might remain. Another mixing and kneading process takes place, and the mixture is ready to enter the mill. In the latest type of mill, two arms close together, catching between them the material for the brick, very much as a coin is stamped in the mint, compressing the brick with upward of 100 to 200 atmospheres pressure.

After compression in the mill the bricks fall out onto a moving platform, and are stacked.

The process is therefore one of great simplicity. A plant of two presses with the necessary equipment capable of turning out together 100 long tons per day of ten hours, requires as the laboring force only one engineer, two men to feed in the coal and the brai, and three boys to stack the briquettes.

In general, these briquettes are preferred to coal, except where the latter is so easily available as to give it the advantage of accessibility. They can be more easily and conveniently handled, and are cleaner because they do not break up readily. A 10 to 15 per cent less quantity of briquettes will give the same heat as coal, and leave less slag, less ash, and less smoke. At Wilhelmshaven some briquettes were left exposed to all weather for three years, and showed no deterioration when used, the tar employed in their manufacture having protected them, so that it is a very serviceable fuel indeed.

Although America has still such an abundance of coal for all purposes, it is by no means sure that the increasing price will not make it economic for us as well to utilize a considerable portion of the coal dust and screenings now wasted, for making briquettes. The cost of manufacturing this fuel, counting everything save the coal dust, is roughly $1.60 per ton. If the product could be sold for $5 a ton, it would probably compete successfully with the best anthracite even at present prices, for the margin of $3.40 should leave a very fair profit, after deducting the cost of the coal dust. So that it is not at all unlikely that the manufacture of coal briquettes is destined ultimately to be a very large American industry as well.

THE STUDY OF ANIMAL MOTION.

Prefacing his more impertinent remarks by a brief historical sketch of the three centuries since the birth of Borelli, the author of the study of animal movements at Naples, Prof. William Stirling, in his discourse before the British Association for the Advancement of Science, said: Nothing was more remarkable than the variety and apparent simplicity of both animal and plant movement. The motor organs that produced them had been more carefully studied than the movements produced. The harmony between the form and functions of a muscle, the co-operation of groups of muscles to produce specific movements were revealed everywhere in animals as well as in the human frame itself. The co-ordination took place in the higher animals in the central nervous system, a system characterized by autonomy as well as centralization. Animal movements might be classified according to the media on or in which the animal moved. In terrestrial progression the ground was a more or less fixed or rigid point of support or fulcrum. The action of the moving limb tended to repel the fulcrum in one direction, and the body itself in the opposite direction. The more solid and resistant the ground, the greater would be the amount of energy available to propel the body forward. The energy, however, was generated by the animal itself. As air was 800 times lighter than water, aerial motion presented the most interesting of all problems. It had been solved by insects and birds alike, and both these flying motors were heavier than air. The air fulcrum was far more mobile than the aquatic or terrestrial support, yet in spite of this the greatest velocities were obtained in aerial progression.

Giovanni Alfonso Borelli was born in Naples in 1608, the son of a Spanish soldier and a Neapolitan mother whose name was Borelli. He became professor of mathematics in Messina about 1640, and in 1656 he was called by Ferdinand Duke of Tuscany to Pisa, where he taught the results of his investigations, and wrote a large part of his work, "De Motu Animalium." Twelve years later he returned to Messina, which he left as an exile in 1674, and went to Rome, where he lived for a time under the patronage of Queen Christina of Sweden. The decennium passed in Pisa was the most brilliant period of his scientific life. Borelli applied to living beings the laws of mechanics, and reduced to its simplest form the theory of animal locomotion, and dealt both with external visible movements and movements of internal organs with voluntary and involuntary movements.

The introduction of exact physical and chemical methods revolutionized physiology, especially from the period of Johannes Müller onward. On the physical side no method contributed more to this advance than the "Graphic Method." A more exact analysis and interpretation of animal movements was not possible until the graphic method had been applied to the study of movements which were either too rapid or of too short duration to be followed by the unaided eye. In physiology the impulse toward the application of the graphic method came through Carl Ludwig in 1847, when he invented the "Kymographion," or wave-writer. Thus for the first time was recorded the beat of the heart as expressed in the variations of pressure within the arteries. The graphic method was rapidly extended to the study of all kinds of physiological and other phenomena. New apparatus in the form of "myographs" and other recording instruments were invented. Time was accurately recorded by vibrating tuning-forks and by chronographs. Problems deemed insoluble a few years before, thanks to the labors and investigations of Helmholtz, Du Bois Reymond, and Prof. Marey, of Paris, were brought within the range of the experimental method. Photography soon lent its aid, and there was a great future for the application of the cinematograph to physiological problems. Lantern slides were shown indicating the changes of form of Amœba, its mode of feeding, movements and reactions to stimuli, as described by Jennings. The observations of Bohn on Atlantic Actina that lived between high and low water mark were next summarized, and the problems suggested by the rhythmically pulsating bells of the Medusæ or jelly-fish illustrated by colored slides reproduced from the works of Allman and Haeckel. The Echinoderms represented by sea-urchins and starfish were also considered. The subject of flight was dealt with briefly, the observations of Da Vinci, Pettigrew, Marey, Lendenfeld, and M. L. Bull at the Marey Institute at Paris being touched on. The last part of the lecture dealt with reflex action as the physiological unit in the operations of the nervous system, the subject being illustrated by the reflex movements of a pithed brainless frog and by the protective reflexes of such animals as crabs, lizards, etc., which amputated a limb or the tail when violently seized. That animals could still execute well co-ordinated movements after certain injuries to the nervous system was made clear by a film showing a frog climbing an inclined plane and maintaining its equilibrium after removal of its cerebrum.

In a concrete bridge, recently completed near Lyons, France, zinc has been used instead of cement to join the stones of two elliptical arches, the span of which is 82 feet. Molten zinc at 800 deg. F. is said to cause no fracture in dry stones, so metallic joints have been formed of ⅛ inch thick. The increase in cost is about 10s. per square foot of the bridge's horizontal surface.

SELENIUM.

Some new phenomena in connection with selenium cells are brought out by H. Pelabon in a paper read before the Academie des Sciences. These cells are of the electrolytic type, but act differently from the ordinary electrolytic selenium cell. The type with which we are familiar consists of two selenium-covered plates in a liquid and we light one plate, keeping the second in the dark. We thus obtain variations in the electromotive force of the cell owing to the action of the light. M. Pelabon uses a cell in which the solution is of trichloride of antimony and the electrodes are two rods, one of pure antimony and the other of an antimony-selenium alloy. The former is the negative pole. Such cells have different properties from the usual kind. When left in the dark, the electromotive force on open circuit reaches a constant value in a few days, when the temperature is kept fixed, and we may call this initial value *a*. Lighting the positive electrode, the electromotive force immediately rises and reaches a value *b*. Then while the light is still kept on, this value begins to diminish, and after about 20 minutes the electromotive force reaches the initial point *a*, which now remains constant. Suppressing the light, the electromotive force diminishes and takes a value *c*, then it rises slowly and in one hour it comes back to the initial point *a*. In an experiment made with a cell in which the electrode is composed of 4 parts antimony and 1 of selenium, the three values are respectively 0.0559 volt (initial); 0.0789 volt (*b*) and 0.359 volt (*c*). We thus have variations which are about half the original value. On closed circuit the results are analogous, but the values are now different, and we have a variation of 1 to 6, which is large. Any proportion of selenium can be used, but the most sensitive cells are those in which the amount of selenium is less. In the latter experiments it was 1 to 99. Sulphur or tellurium cannot be used to replace the selenium, and this latter is necessary. Other metals can be used instead of antimony. No effect is given by ultra-violet rays, and but little by blue rays.

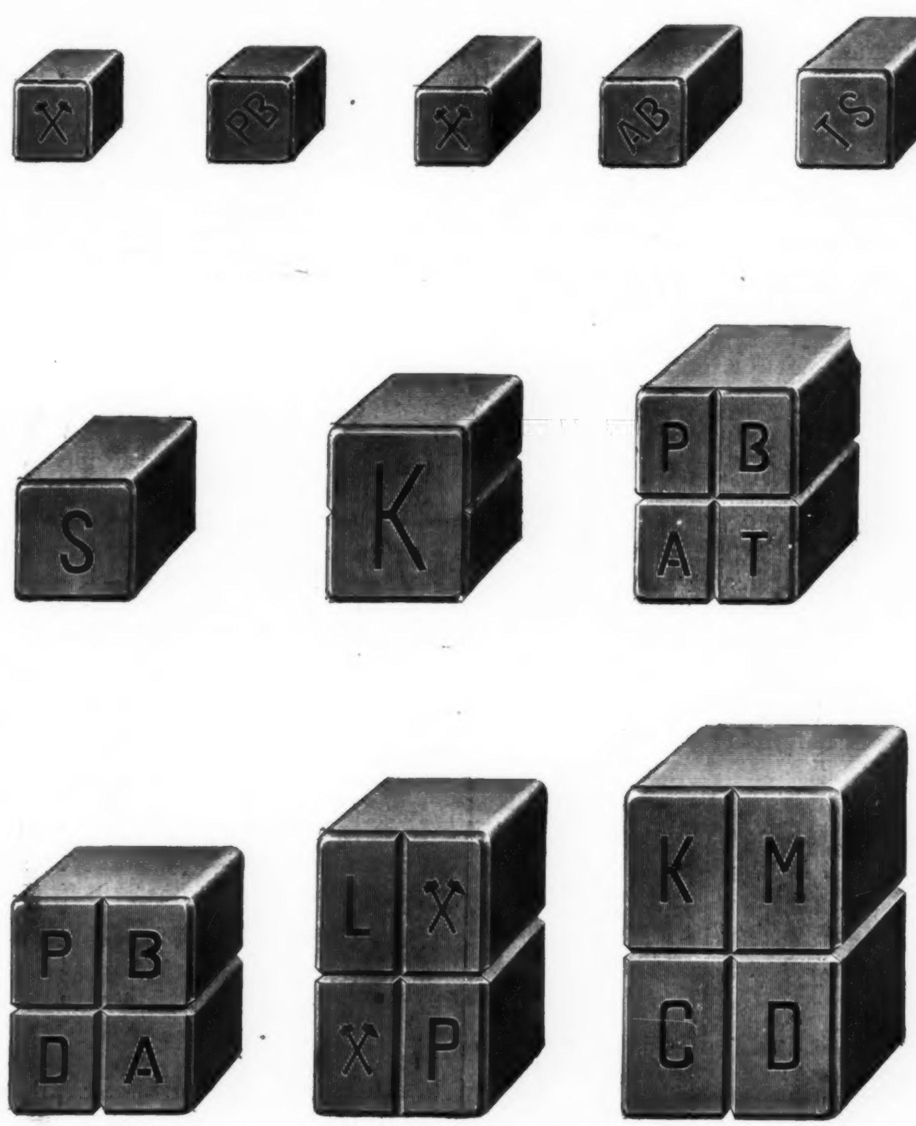


Fig. 6.—Samples of Briquettes.

THE PONS ASINORUM.—II.*

NEW SOLUTIONS OF THE PYTHAGOREAN THEOREM.

BY ARTHUR R. COLBURN, LL.M., OF THE DISTRICT OF COLUMBIA BAR.

Concluded from Supplement No. 1822, page 359.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares of the other two sides.

Solution 7.—Let triangle ABC be a right triangle, with the right angle at B. Complete the square upon AB, as $ADEB$. Draw the perpendicular from B to the hypothenuse AC, and designate the intersection as H. Draw DC; draw DG parallel to AC; draw AF and CG perpendicular to AC.

$AF=AH$; for triangle AFD=triangle AHB, being perpendicular right triangles, and the hypothenuse of one equals the hypothenuse of the other.

The triangle DAC has ½ the area of the square DB.

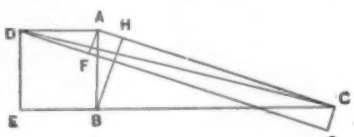


Fig. 7.

(having the same base, AD, and the same altitude, AB).

The triangle DAC has ½ the area of the parallelogram AG (having the same base, AC, and the same altitude, AF).

Therefore, square DB=parallelogram AG.

(Thus, the comparison of triangles, as in Euclid's solution, is eliminated, the triangle being common to both.)

Therefore, the square on the hypothenuse is equal to the sum of the squares on the other two sides, in a right triangle.

For the parallelogram AG=square FH + parallelogram HG; and the parallelogram $HG = AH \times HC$, and $\overline{BH}^2 = AH \times HC$ (since BH is a mean proportional between AH and HC).

The square on the hypothenuse of a right triangle is equal to the sum of the squares of the other two sides.

Solution 8.—Let triangle ABC be a right triangle, with the right angle at B. Complete the square on AB, as square AB'; construct square on BC, as square CC'; draw $B'C'$.

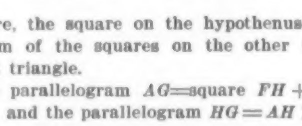


Fig. 8.

$B'C'=AC$ (for triangle ABC=triangle $B'BC'$). Draw $B'A'$ perpendicular to $B'C'$.

Then $A'B \times BC'$ (or BC)$=\overline{BB'}^2$ (or $\overline{AB}^2$). Complete the parallelogram $A'BCD$.

Then parallelogram $A'C$=square AB;

And parallelogram DC'=square AB + square BC.

But $B'C'$ is a mean proportional between $A'D$ and $A'C'$ (as $A'D$=BC').

Then parallelogram $DC'=\overline{B'C'}^2$ (=$\overline{AC}^2$).

Therefore $\overline{AC}^2=\overline{AB}^2+\overline{BC}^2$.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 9.—Let triangle ABC be a right triangle, with the right angle at B. Draw BD perpendicular to AC. Draw AE=AD and perpendicular to AD.

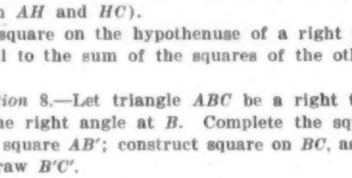


Fig. 9.

Draw CF parallel to AE and =AE. Draw FE and produce same, as to G.

FE produced passes through the corner, G, of the square on AB; for the triangle AEG=triangle ADB, (being perpendicular triangles, and the short side of one equals the short side of the other).

Draw GC.

Triangle GAC=½ square AB (having same base, AG, and same altitude, AB).

Triangle GAC=½ parallelogram AF (having same base, AC, and same altitude, AE).

Therefore square AB=parallelogram AF.

But parallelogram AF=square AE+parallelogram DF.

And parallelogram $DF=\overline{DB}^2$ (DB being a mean proportional between AD and DC).

Therefore the square AB, on the hypothenuse of the right triangle ADB, equals the sum of the squares on the other two sides. As triangle ADB is similar to triangle ABC, then the same is true of the triangle ABC.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 10.—Let triangle ABC be a right triangle, with a right angle at B. Erect squares on sides AB and BC, outside the said triangle. Erect the square on the hypothenuse AC, so as to include the triangle, marking the intersection near B as D. Draw DE

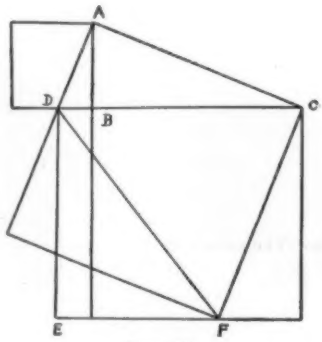


Fig. 10.

parallel to AB, and complete the parallelogram BE. The perpendicular to AC from C will end in the side of the square on BC, as at F. (AC and CF being equal hypothenuses of similar, and therefore equal, right triangles, perpendicular to each other, and having the long side of one equal to the long side of the other.)

Parallelogram BE=square AB (since AB is a mean proportional between DB and BC, or its equivalent, DE).

Then parallelogram CE=square AB + square BC. Draw DF.

The triangle DCF is contained within each, and is common to both, the square on the hypothenuse AC, and the parallelogram CE.

The triangle DCF=½ square AC (having same base, CF, and same altitude, AC).

The triangle DCF=½ parallelogram CE (having same base, DC, and same altitude, DE).

Therefore, square AC=parallelogram CE=square AB + square BC.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 11.—For convenience, designate the short side, and the long side, and the hypothenuse of a right triangle, as elements x, y, and z, respectively.

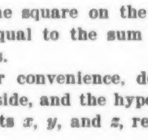


Fig. 11.

Erect the squares on x and y outside the triangle.

Complete the two parallelograms, xy, as shown.

The area of the outer square, thus formed, can be expressed as $x^2+2xy+y^2$.

Erect the square upon z, within the outer square, $(x+y)^2$.

The corners of the square upon z will fall upon the lines of the outer square; for perpendicular, and therefore similar, right triangles are successively formed about the square upon z; and, having equal homologous sides, namely, the long side of each right triangle, they are all equal triangles, having the sides of the square on z as their hypothenuses.

Then the area of the outer square is equal to the square on z, and the area of the four outer triangles, each being ½ xy; as: $z^2 + 4\left(\frac{xy}{2}\right) = z^2 + 2\,xy$. Then $x^2 + 2\,xy + y^2 = z^2 + 2\,xy$. Therefore, $x^2 + y^2 = z^2$.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 12.—Let triangle ABC be a right triangle, with right angle at B. Erect the square on AB, as $AHIB$; and the square on BC, as $BDEC$; and on AC, as $AFGC$. Produce FA to IB, as at K.

Then AB is a mean proportional between KB and BC.

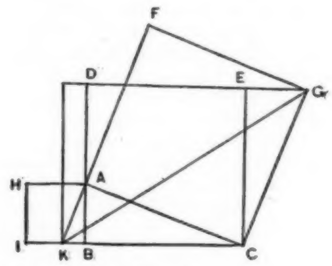


Fig. 12.

Therefore $\overline{AB}^2=KB \times BC$ (or $KB \times BD$). Complete the parallelogram KD.

Parallelogram KD=square $AHIB$.

Draw a perpendicular from G to the line CE, produced if necessary; the triangle thus formed on the line CG will be a right triangle perpendicular to triangle ABC, and, having equal hypothenuses, is equal thereto; therefore said perpendicular will fall upon the point E (since BC=EC), and DE and EG form one straight line; therefore DE produced passes through the corner G of the square. Draw KG.

Triangle KCG=½ parallelogram KE (having same base KC and same altitude, CE).

Triangle KCG=½ square AC (having same base CG, and same altitude, AC).

Therefore square AC=parallelogram KE=square AB + square BC.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 13.—Let triangle ABC be a right triangle, with right angle at B. Erect the squares on the three sides, as $ADEB$, $BFGC$, and $AHIC$. Draw IK parallel to CB. Draw CL perpendicular to IK. Produce HA to EB, as at M. Draw ON perpendicular to EB through M. Draw OF parallel to EB.

Triangle PHI=triangle MAC (being parallel to each other, and HI=AC, by construction).

Triangle ILC=triangle PNM (being parallel, and NM=LC, being parallels between intersecting parallels).

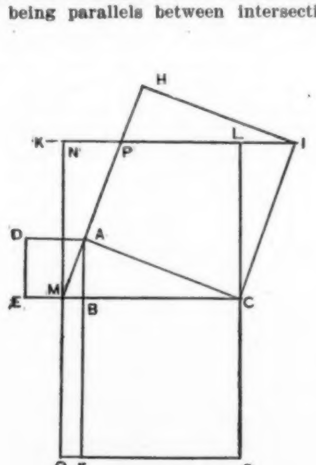


Fig. 13.

Therefore parallelogram NC=square HC (polygon $PLCA$ being common to both).

Parallelogram MF=square DB (since AB is a mean proportional between MB and BC).

Therefore parallelogram MG=sum of squares on AB and BC.

Triangle ILC=triangle ABC (being perpendicular, and having IC=AC).

Therefore GC=LC.

Therefore parallelogram NC=parallelogram MG.

Therefore square AC=square AB+square BC.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides and to do so, triangulating the one and then the other two together, and proving the triangles identical or equal.

Solution 14.—Let the triangle ABC be a right triangle, with right angle at B. Erect the square $ADEC$ on hypothenuse, AC; and the square $CFGB$ on side, BC; and the square on the side, AB. Produce EC to GF, as at H. CH=AC (since triangle HFC= triangle ABC, being perpendicular thereto, therefore, similar, and having FC=BC); and AC=EC.

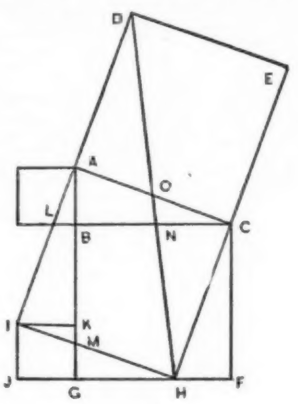


FIG. 14.

Then AB=HF. Draw DH. Triangle DEH=square AE; (having the same altitude, DE, and twice the base, as EH). (Note: DH will always bisect AC.)

To place the areas of square AB + square BF into a triangle, to equal triangle DEH:

Complete the square $ACHI$.

Produce FG to J so that GJ=HF (=AB); then HJ=FG. Draw IJ; draw IK perpendicular to BG. Comparing triangles IJH and ABC, angle IHJ=angle ACB, (being parallel), IH=AC, and JH=BC; therefore they are equal triangles, having two sides and the included angle of one equal to the same of the other;) then angle J is a right angle, and IJ=AB (=HF=JG). IJ and KG are parallel, and parallelogram JK is a square, and is equal to square AB. Triangle DHI=triangle DEH (since DH is a diagonal of parallelogram EI).

The area of the figure $BNHM$, of the square BC, remains within the triangle DHI.

Consider the area of triangle IJH as placed within its equivalent triangle ABC; (this carries with it the area of the square AB, excepting the triangle IKM, which is equal to triangle ABL, being perpendicular thereto, and having IK=AB).

Let triangle IKM represent the area of triangle ABL of square AB.

Let triangle IKA represent triangle HFC of the square BC, (being parallel triangles, having homologous sides equal).

And triangle HCO=triangle DAO (being parallel, and symmetrical, and having equal sides and angles).

Therefore triangle DHI=square AB + square BC= triangle DEH=square AC.

The square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 15.—Given the right triangle ABC, with right angle at B. Erect the square on the hypothenuse AC; erect within the angle B the squares upon AB and BC; through their corners, as F, or G, within the square $ADEC$ upon the hypothenuse draw a line

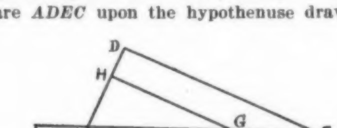


FIG. 15.

parallel to AC and intersecting the sides of the square on the hypothenuse, as JK, or HI.

To prove parallelogram JC=square BF, and parallelogram DK=square BG; or parallelogram DI=square BF, and parallelogram HC=square BG.

Let both of such parallels be drawn. Draw FC.

Triangle AFC=½ of square AB (same base AF and altitude AB)=½ of parallelogram JC (same base AC and altitude AJ).

Therefore parallelogram JC=square BF. Draw GE.

In parallelograms JC and DI, GE (=AB) =AF; for triangle EGC=triangle ABC (having CE=AC, GC= BC, and angle ECG perpendicular to angle ACB); then triangle EIG=triangle AJF (being parallel, and GE= AF); therefore EI=AJ.

Therefore, parallelogram DI=parallelogram JC (= square BF).

Therefore, parallelogram DK = parallelogram HC (having HK with equal complements). Draw AG.

Triangle AGC=½ square BG (same base GC and altitude BC)=½ parallelogram HC (same base AC and altitude IC).

Therefore parallelogram DK=parallelogram HC= square BG.

Therefore $\overline{AB}^2+\overline{BC}^2=\overline{AC}^2$.

Solution 16.—Variation of solution 15. In this, the point B represents points F and G of the preceding solution; the one dividing parallel JK is drawn through B parallel to AD; BD repre-

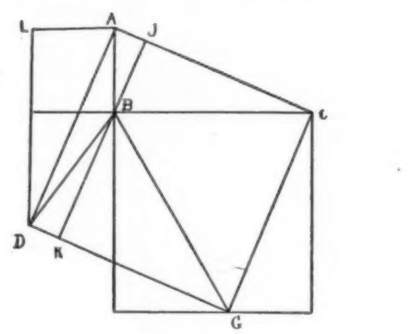


FIG. 16.

sents FC, and BG represents AG of the preceding solution. In this one, triangle ALD=triangle ABC (being perpendicular, and having AD=AC and AL= AB). The remainder of this solution is obvious, in view of the preceding solution, justifying the conclusion,

$$\overline{AB}^2+\overline{BC}^2=\overline{AC}^2.$$

Theorem.—The square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 17.—In this diagram the construction is obvious. Given the right triangle A, construct the square on the hypothenuse so as to include the triangle, and by perpendiculars from the corners of the square construct the other three included triangles, and by parallels construct the two outer triangles, and show the square at the lower end of the diagram. The six triangles thus constructed are all either parallel or perpendicular to each other and all have equal hy-

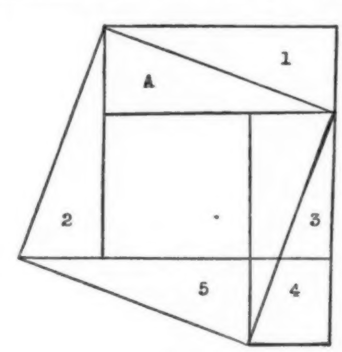


FIG. 17.

pothenuses, and are therefore equal right triangles. Squares of the two sides of the triangle are shown, and the portions thereof which are outside the square on the hypothenuse can, by substitution of equivalent areas, be placed within the square. Substitute triangle No. 2 for No. 1; and No. 5 for elements 3 + 4. This occupies the entire area of the square on the hypothenuse.

Theorem.—The square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 18.—Let ACB be a right triangle, with right angle at C.

(C may be at any point in a semicircle upon AB.)

Draw the square $ABFE$ on the hypothenuse AB. Through the right angle C draw DH perpendicular to AB, intersecting opposite sides of the square.

NOTE.—In "Famous Geometrical Forms and Problems," Parts I. and II., by William W. Rupert (Heath's Mathematical Monographs), there are 26 proofs of the Pythagorean theorem. No. VIII. of this set is the same as the one numbered 10 of Mr. Colburn's proofs, given by the last-named in this collection. Heath's Monographs can be easily obtained by any one interested in the subject.—EDITOR.

Rectangle $DE=\overline{AC}^2$ (since AC is a mean proportional between AD and AB; and $AB=AE$).

Rectangle $DF=\overline{BC}^2$ (since BC is a mean proportional between BA and BD; and $BA=BF$).

Therefore, $\overline{AC}^2+\overline{BC}^2=\overline{AB}^2$.

The foregoing diagram affords a new method of finding the mean proportional between two dimensions.

With two given dimensions construct a rectangle; produce the short side until equal to the long side; upon the line so produced draw a semicircle; from

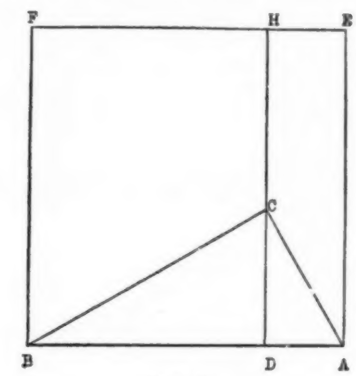


FIG. 18.

the point of intersection of the arc and side of the rectangle draw a line to the corner of the rectangle at the end of the semicircle; such line is the desired mean proportional, and represents a square equal to the rectangle.

EXPERIMENTS IN BLUEBERRY CULTURE.

AN interesting and significant feature in the experiments reported in Bulletin 193, of the Bureau of Plant Industry, just issued by the United States Department of Agriculture, is the light shed on the possible utilization of naturally acid lands that occupy extensive areas in the Eastern United States, to produce the delicious blueberry or some other crop that thrives in acid soils.

The department has found by experiment how blueberries differ from ordinary plants in their methods of nutrition and in their soil requirements, and by means of this knowledge it has worked out a system of pit culture under which these plants attained a development beyond all previous expectations. The failure heretofore of attempts to cultivate blueberries commercially as a market fruit, appears to be due to a misunderstanding of the soil requirements of the plants, which, as these experiments show, are radically different from those of our common cultivated plants.

The market would gladly pay a higher price for cultivated blueberries of superior quality. A marked distinction should be made in market quotations between the large plump blueberry (genus Vaccinium), whose seeds are so small as to be almost unnoticed when they are being eaten, and the huckleberry (genus Gaylussacia) in which the seed is surrounded by a bony covering like a minute peach pit, which crackles between the teeth. The failure to make this distinction in nomenclature, and the unsightly condition in which careless handling often presents the berries to the buyer, are the cause of much of the failure in Southern markets to appreciate the blueberry at its real value. As the blueberry withstands the rough treatment incident to shipment so much better than most other berries, with proper handling it should always reach the market in first-class condition, whether shipped from North Carolina to Boston in early June, or Nova Scotia to Washington in late September, making the blueberry season cover a period of nearly four months.

To those desiring to experiment with field culture of the swamp blueberry, whether with wild plants, seedlings, or plants grown from cuttings, two methods of treatment are suggested, both deduced from the experiments already made. The first method, suited to upland soils, is to set the plants in trenches or separate holes in well-rotted peat at least a foot in depth, and mulch the surface well either with leaves or with clean sand. The excavations should provide ample space for new growth of the roots, and the peat used may be either of the bog or upland type, and should have been rotted for several months before using. The soil should afford good drainage, the ideal condition of the peat about the roots of the plant being one of continued moisture during the growing season, but with all the free water draining readily so that thorough aeration of the mass of peat is assured.

The second method of field culture suggested is to set the plants in a peat bog after the bog has been drained, turfed, and deeply mulched with sand, just as for cranberry culture, except that no special provision need be made for rapid flooding of the bog for winter, and the ground water of the bog might be kept a little lower than is usual with cranberries. Before beginning the work, these experiments should be carefully studied by any one proposing to undertake the culture of blueberries.

ENGINEERING NOTES.

A patent has been granted to F. Leptien for an apparatus which produces low temperatures by expansion, with the performance of external work, of compressed gases. The cylinder in which the expansion of the compressed gas is allowed to take place is heat-insulated at the part which does not come into contact with the piston packing, by means of a vacuum chamber divided into compartments. The piston is provided with strong spring packing rings, which, pressing heavily on the cylinder walls, prevent leakage and generate sufficient heat to keep the lubricant in a fluid condition.

In a lecture delivered at Sir John Cass Technical Institute, J. S. S. Brame pointed out that the introduction of power gas has made possible considerable economy in the use of natural fuel resources. Apart from the use of blast-furnace and coke-oven gas, previously wasted, the replacement of steam power by gas power would diminish the annual consumption of coal for power in this country by 9 million tons, or about 20 per cent. Power gas can also be generated from peat and other poor fuels not suitable for raising steam. There are 140 million acres of peat bog in Europe. For small powers, up to 30 brake horse-power, the author recommends the use of coal-gas rather than a gas plant; from 30 to 250 brake horse-power a suction gas plant is recommended; and for greater power, a pressure gas plant. The success of the suction gas plant using bituminous fuel is now established. Recent developments are the use of the engine exhaust in place of steam in the producer, and, in Germany the abolition of the gas holder in pressure gas plants, the production being controlled by fans driven by the engine.

Some very important experiments on an exploded boiler tube were made by E. Heyn and O. Bauer, of the Königl. Materialprufungsamt. The following indicates briefly the sections under which the tube was examined and the general deductions: (1) Careful measurements were made throughout the tube showing the thickness to be far from uniform. (2) The burst took place at the thinnest section. (3) Two lengths of the tube tested to destruction with hydraulic pressure gave the same conclusion, although they proved much stronger than the section which burst. (4) A preliminary microscopic examination showed the material to be free from slag, cinder, and other impurities, and that it was seamless. (5) An examination of the outside showed that the iron had been attacked by sulphurous acid from the fire gases, producing, in parts, iron sulphide. This action does not take place below 400 deg. C., showing that overheating had taken place in these parts. (6) The neighborhood of the fracture when properly prepared exhibited a martensitic structure, a form not produced under 700 deg. C. Other parts of the tube giving a normal structure when first cut from the tube could be given a martensitic structure when heated to 900 deg. C. and quenched in cold water. The final conclusion is that failure was due to prolonged overheating, but the cause of the latter does not seem to have been cleared up.

ELECTRICAL NOTES.

In a paper read before the Belfast Association of Engineers, A. Blair and J. F. Wilson discuss electric propulsion of ships. They explain how their system could be adapted on the Midland Railway Company's steamer "Londonderry," 330 feet long, 42 feet wide, at present equipped with three turbo-driven propellers of 6,300 s.h.p. total, for a speed of 21 knots. Two sets of three-phase turbo-generators would be installed, each 2,400 kw., 4-pole, 40-~, 1,200 r.p.m., 2,000 volts, 0.9 power factor, with 150 pounds steam pressure at 100 deg. F. superheat, and 11 pounds steam consumption per i.h.p.; weight, 30 tons; rotor diameter, 3 feet 9 inches; length, 3 feet 4 inches; external diameter of stator, 5 feet 6 inches; generator efficiency, 96 per cent. Two propellers would each be driven by a 2,870-b.h.p. three-phase, 16-pole, 300-r.p.m. squirrel-cage motor weighing 35 tons, with rotor 6 feet 3 inches diameter, and 4 feet long; stator, 8 feet external diameter. For running all auxiliaries, two 250-b.h.p. gas-driven three-phase generators, one as a standby, would be provided, suction gas for this purpose being considered cheaper than steam, and more suited to varying loads. The similarity in the requirements for the motors on the Simplon tunnel locomotives and those for ship propulsion is pointed out, and various methods for speed variation are discussed.

In the Journal of the Institute of Electrical Engineers, Mr. W. P. Digby explains how water may be examined by electrical methods. His object, he tells us, was to devise a simple test which could be made *in situ*, and would serve to indicate when a boiler feed-water required the attention of an analytical chemist. The method adopted is that of determining the electrical conductivity at a predetermined temperature and of comparing the figure obtained with that of samples containing known amounts of impurity. The form of apparatus employed for practical determinations of specific resistance or conductivity consists of a glass U-tube to which is attached, to the lowest point of the bend, a tube brought from the supply funnel. Near the end of the extremities of limbs of the main tube, overflow side tubes are provided. The electrodes are open cylinders of Pt, about 9 millimeters in diameter and 3 millimeters in height, connected by three equidistant Pt-wires to stout brass glass-covered rods, passing through the brass covers which are connected to the terminals. The apparatus contains 10 cubic centimeters of water when fully charged. The specific resistance or "conductance" is measured by a "conductance meter" specially manufactured for use with this apparatus. It resembles the familiar "megger," but is furnished with a scale graduated in reciprocal megohms and ohms. A large number of diagrams are given showing the results obtained with this instrument when applied to solutions of sodium carbonate, sodium sulphate, calcium carbonate, sea-water, tap-water, and to water taken from boilers while operating. The author claims that this method of determining the electrical conductivity of liquid offers to the engineer: (*a*) The knowledge when the analyst should be called in, to report upon the nature and probable effect of a change in the constitution of a feed-water, as indicated by the conductance meter. (*b*) The knowledge as to whether condensers are leaking, and the amount of the leakage; so that the date for overhauling can be settled promptly. (*c*) An exact determination of the amount of priming arising in any type of boiler under *any* defined conditions of load, water-level, or nature of water. (*d*) The control of oil-eliminating plants, preventing the inadvertent addition of injurious constituents to the boiler-feed. (*e*) The control of water-softening plants.

SCIENCE NOTES.

A. Stock and H. Heynemann have made some experiments with the sun as a heat source in chemical experiments. If the substance to be heated be contained in an exhausted glass vessel, the heat can be concentrated upon the substance itself, so that a very highly refractory supporting vessel is not required. The apparatus employed was a plano-convex lens of 40 centimeters diameter and 50 centimeters focal length being used to concentrate the sun's rays on to the substance which was itself placed in a magnesia crucible. Pieces of copper and cast iron were melted almost instantly, while crystallized Si (melting point 1,450 deg. C.) was melted in a few seconds. A thermo-junction supported at the center of the flask gave a reading of 1,030 deg C. *in vacuo;* a reading unexhausted indicated only 675 deg. C.

Some new refrigerating liquids have been devised by W. E. Evans, an English inventor. An hermetically sealed apparatus consisting of two communicating vessels in which a high vacuum has been produced is used. Water containing a hygroscopic substance in solution (such as zinc chloride or caustic potash) is charged into one vessel and a small quantity is also placed in the second vessel. The first vessel is heated and the second vessel cooled, so that water distils over and is condensed in the second vessel. The first vessel is now cooled and the second vessel surrounded by the liquid to be frozen. The water in the second vessel re-evaporates and is re-absorbed rapidly by the salt in the first vessel, producing a low temperature in the second vessel. The small quantity of the salt in the second vessel prevents its contents freezing.

How mirrors are made from metallic sulphides is described by O. Hauser and E. Biesalski in the Chem. Zeit. Thiourea in aqueous or alcoholic solution is decomposed by alkalis, with production of hydrogen sulphide; and if metallic salts, especially lead salts, be present in solution, the sulphides formed are deposited on glass as closely adhering films. For example, a glass plate 9 by 12 centimeter is supported on four paraffin blocks in a developing dish; a solution of 1 gramme of thiourea in 50 to 75 cubic centimeters of water is poured over it, then 50 to 75 cubic centimeters of a dilute solution of lead acetate are added, and finally 25 to 50 cubic centimeters of dilute sodium hydroxide solution or ammonia. In half an hour or more, the glass plate is coated on both sides with lead sulphide; it is now washed with water and dried, and the upper coating rubbed away, leaving the other as a mirror under the glass.

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